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FOR
TESTING MATERIALS

AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS

PROCEEDINGS
OF THE
TWENTIETH ANNUAL MEETING

Held at Atlantic City, New Jersey
June 26–29, 1917

VOLUME XVII

PART I. COMMITTEE REPORTS
TENTATIVE STANDARDS

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CONTENTS.

PROCEEDINGS.

PAGE

Summary of the Proceedings of the Twentieth Annual Meeting......... 9

Our Society—Annual Address by the President, A. A. Stevenson........ 34

Addresses by Past Presidents:

A. W. Gibbs........ 50

Arthur N. Talbot........ 51

Robert W. Hunt........ 52

Henry M. Howe........ 54

Mansfield Merriman........ 55

Annual Report of the Executive Committee........ 56

Appendix. Abstract of the Minutes of the Executive Committee... 73

COMMITTEE REPORTS.

Ferrous Metals.

Report of Committee A-1 on Steel........ 86

Appendix I. Proposed Revisions in Specifications for Steel and Steel Products........ 97

Appendix II. The Rail Situation........ 111

Appendix III. Calculation of Energy Expended in Bending a Beam 115

Addendum to Report of Committee A-1........ 118

Discussion........ 121

Report of Committee A-2 on Wrought Iron........ 130

Report of Committee A-3 on Cast Iron........ 133

Discussion........ 135

Report of Committee A-5 on Corrosion of Iron and Steel........ 143

Appendix. Report of Sub-Committee II on Preservative Metallic Coatings for Metals........ 144

Discussion........ 175

Non-Ferrous Metals.

Report of Committee B-2 on Non-Ferrous Metals and Alloys........ 178

Appendix I. Proposed Revisions in Standard Specifications for Spelter........ 180

Appendix II. Report of Sub-Committee III on Sand-Cast Metals and Alloys........ 182

Addendum to Report of Committee B-2........ 195

Cement, Lime and Clay Products.

Report of Committee C-1 on Cement........ 196

Discussion........ 198

PAGE
Report of Committee C-2 on Reinforced Concrete 201
  Final Report of the Joint Committee on Concrete and Reinforced Concrete 202
  Discussion 263
Report of Committee C-4 on Clay and Cement Sewer Pipe 293
Report of Committee C-5 on Fireproofing 295
  Discussion 300
Report of Committee C-6 on Drain Tile 311
Report of Committee C-7 on Lime 312
Report of Committee C-8 on Refractories 313
  Appendix. Slag Test for Refractory Brick Used in the Iron and Steel Industry—C. E. Nesbitt and M. L. Bell 314
Report of Committee C-9 on Concrete and Concrete Aggregates 319
  Appendix I. Suggested Methods for Making and Testing Field Specimens of Concrete 322
  Appendix II. Suggested Colorimetric Tests for Organic Impurities in Sand 327
  Appendix III. Report of Joint Conference Committee of Committees C-9 and D-4 on Provisional Definitions, Tests and Methods Pertaining to Non-Bituminous Road Materials 334
Report of Committee C-10 on Hollow Building Tile 335
  Appendix I. Compression Tests of Tile 338
  Appendix II. Absorption Tests of Tile 353
  Appendix III. Tests of Tile Walls 359

Miscellaneous Materials: Preservative Coatings, etc.

Report of Committee D-1 on Preservative Coatings for Structural Materials 363
  Report of:
    Sub-Committee III on Testing of Paint Vehicles 365
      Appendix I. Reports of Analysts on Lumbang and Perilla Oils 366
      Appendix II. Preliminary Report Made in compliance with the Department of State's Instruction concerning the Sources of Lumbang and Perilla Oils 375
    Sub-Committee V on Linseed Oil 377
      Appendix. Reports of Analysts 378
    Sub-Committee VIII on Methods of Analysis of Paint Materials 385
    Sub-Committee IX on Varnish 386
      Appendix. Reports of Analysts 390
    Sub-Committee XI on Paint Thinners other than Turpentine 402
      Appendix I. Tests of 1914 Series 410
      Appendix II. Tests of 1915 Series 431
      Appendix III. Tests of 1917 Series 443

Report of Committee D-1 (*Continued*) **PAGE**

Sub-Committee XIV on the Preparation of Iron and Steel Surfaces for Painting.............................. 451

Appendix. Record of Preparation and Painting of Surfaces as Outlined in Tentative Schedule of Tests........... 454

Sub-Committee XV on Specifications for Pigments Dry and in Oil when Marketed in the Form.... 458

Addendum to Report of Committee D-1......................... 460

Report of Committee D-2 on Lubricants......................... 462

Report of Committee D-4 on Road Materials........................ 470

Appendix I. Proposed Tentative Revision of Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment.. 474

Appendix II. Report on British Standard Nomenclature of Bituminous Materials.. 476

Report of Committee D-7 on Timber................................ 483

Report of Committee D-8 on Waterproofing......................... 487

Report of Committee D-9 on Electrical Insulation.................. 489

Discussion.. 491

Report of Committee D-10 on Shipping Containers.................. 493

Report of Committee D-11 on Rubber Products...................... 494

Report of Committee D-13 on Textile Materials..................... 497

Miscellaneous Subjects.

Report of Committee E-1 on Methods of Testing..................... 499

Appendix. Report of Sub-Committee on Effect of Form and Size and Test Piece.. 502

Report of Committee E-3 on Revision of Pipe Threads................ 504

Report of Committee E-4 on Magnification Scales for Micrographs...... 508

Discussion.. 509

Report of Committee E-5 on Standing Committees.................... 512

Appendix I. Changes in the Regulations Governing Standing Committees... 516

Appendix II. Statement of Sub-Committee on Classification of Standing Committees and Standards.................... 519

Report of Committee E-6 on Papers and Publications................ 529

TENTATIVE STANDARDS.

A. FERROUS METALS.

Steel.

Tentative Specifications for:

A 65–16 T. Steel Track Spikes............................ 537

A 66–16 T. Steel Screw Spikes............................ 539

A 67–17 T. Steel Tie Plates.............................. 541

Tentative Specifications for: PAGE

A 68–16 T. Carbon-Steel Bars for Railway Springs with Special Silicon Requirements 546
A 69–16 T. Elliptical Springs for Automobiles 549
A 70–17 T. Boiler and Firebox Steel for Stationary Service 557
A 71–17 T. Carbon Tool Steel 562

Wrought Iron.

Tentative Specifications for:

A 39–17 T. Staybolt Iron 564
A 72–17 T. Wrought-Iron Pipe 568
A 73–17 T. Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars 573

Cast Iron.

Tentative Specifications for:

A 74–17 T. Cast-Iron Soil Pipe and Fittings 576
A 75–17 T. Railroad Malleable-Iron Castings 582

B. NON-FERROUS METALS.

Tentative Specifications for:

B 10–15 T. The Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent 585
B 11–16 T. Copper Plates for Locomotive Fireboxes 588
B 12–16 T. Copper Bars for Locomotive Staybolts 592
B 13–16 T. Seamless Copper Boiler Tubes 595
B 14–16 T. Seamless Brass Boiler Tubes 599
B 15–17 T. Brass Forging Rod 603
B 16–17 T. Free-Cutting Brass Rod for Use in Screw Machines 606
B 17–17 T. Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings 610
B 6–17 T. Spelter 615

Tentative Methods for:

B 18–17 T. Analysis of Alloys of Lead, Tin, Antimony and Copper 622

C. CEMENT, LIME, GYPSUM AND CLAY PRODUCTS.

Tentative Specifications for:

C 9–16 T. Specifications and Tests for Compressive Strength of Portland-Cement Mortars 630
C 13–17 T. Clay Sewer Pipe 634
C 14–17 T. Cement-Concrete Sewer Pipe 647

Tentative Specifications for: PAGE

C 15–17 T. Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling.............. 659
C 6–17 T. Masons' Hydrated Lime......................... 661

Tentative Tests for:

C 16–17 T. Refractory Materials under Load at High Temperatures.................................. 665
C 17–17 T. Slagging Action of Refractory Materials........... 669

Tentative Methods for:

C 18–17 T. Ultimate Chemical Analysis of Refractory Materials.................................... 671
C 19–17 T. Control of Fire Tests and Classification of Materials and Construction as Determined by Test........ 679

Tentative Definitions of:

C 11–16 T. Terms Relating to the Gypsum Industry.......... 681

Tentative Recommended Practice for:

C 12–17 T. Laying Sewer Pipe............................ 701

D. MISCELLANEOUS MATERIALS.

Tentative Specifications for:

D 23–16 T. Selected Structural Douglas Fir Bridge and Trestle Timbers.................................... 704
D 24–15 T. Southern Yellow-Pine Timber to be Creosoted..... 708
D 25–15 T. Southern Yellow-Pine Piles and Poles to be Creosoted...................................... 710
D 40–17 T. Asphalt for Use in Damp-proofing and Waterproofing..................................... 712
D 41–17 T. Primer for Use with Asphalt for Use in Damp-proofing and Waterproofing................... 716
D 42–17 T. Coal-Tar Pitch for Use in Damp-proofing and Waterproofing.............................. 717
D 43–17 T. Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing... 721
D 44–17 T. Canned Foods Boxes, Nailed and Lock-Corner Construction.............................. 723
D 45–17 T. Canned Foods Boxes, Wirebound Construction.... 730
D 26–16 T. 2½, 3 and 3½-in. Double-Jacketed Cotton Rubber-Lined Fire Hose for Public Fire Department Use. 732
D 27–16 T. Insulated Wire and Cable: 30 per cent Hevea Rubber...................................... 737
D 46–17 T. Air-Line Hose for Pneumatic Tools............... 763

Tentative Tests for:

PAGE
D 47–17 T. Lubricants 767
D 3–17 T. Toughness of Rock 773
D 30–17 T. Determination of Apparent Specific Gravity of Coarse Aggregates 776
D 48–17 T. Molded Insulating Materials 778
D 31–16 T. Automobile Tire Fabrics 791
D 32–16 T. Cotton Fabrics for Use in Hose, Belting, and Similar Articles 793
D 33–16 T. Cotton Fabrics for Use in Bags and Bagging Material 794

Tentative Methods for:

D 49–17 T. Routine Analysis of Dry Red Lead 796
D 50–17 T. Routine Analysis of Yellow, Orange, Red, and Brown Pigments containing Iron and Manganese 802
D 35–16 T. Form of Specifications for Certain Commercial Grades of Broken Stone 810
D 36–16 T. Determination of Softening Point of Bituminous Materials other than Tar Products 811
D 37–16 T. Laboratory Sampling and Analysis of Coke 813
D 38–17 T. Analysis of Creosote Oil 826
D 39–16 T. Testing Cotton Fabrics 829

Tentative Definitions of:

D 8–17 T. Terms Relating to Materials for Roads and Pavements 836

E. MISCELLANEOUS SUBJECTS.

Tentative Definitions:

E 2–17 T. Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys 838

List of Tentative Standards 842
Tentative Revisions of Standards 849
Officers and Members of the Executive Committee 851
Subject Index 852
Author Index 868

SUMMARY OF THE PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING.

Atlantic City, N. J., June 26–29, 1917.

The Twentieth Annual Meeting of the American Society for Testing Materials was held at the Hotel Traymore, Atlantic City, N. J., June 26–29, 1917. The following is an analysis of attendance at the meeting: Members, in attendance or represented, 507; guests, 90; ladies, 154; total, 751; the corresponding statistics for the Nineteenth Annual Meeting in 1916 being: Members, in attendance or represented, 455; guests, 74; ladies, 130; total, 659.

The names of the members who were present or represented are given in the appendix to this summary.

First Session—Tuesday, June 26, 11 a. m.

President A. A. Stevenson in the chair.

The President referred to the absence, on account of illness, of the Secretary-Treasurer, Mr. Edgar Marburg. The following resolution, introduced by Mr. L. W. Page, was unanimously adopted and telegraphed at once to Mr. Marburg:

> "The American Society for Testing Materials, at its opening session, sends its best wishes for a speedy recovery to its Secretary-Treasurer, whose high ideals and faithful service have done so much to make this organization what it is. Each member present desires to assure Doctor Marburg that he will endeavor to make this meeting the success that the Society's honored Secretary-Treasurer would have it."

The minutes of the Nineteenth Annual Meeting were approved as printed.

The President appointed Mr. E. E. Hughes and Mr. Robert Job as tellers to canvass the vote for officers.

The Assistant to the Secretary presented the annual report of the Executive Committee. The proposed amendments of the by-laws recommended by the Executive Committtee were approved without change for reference to letter ballot.

The Assistant to the Secretary called attention to the following paragraph in the report:

> "It has been suggested that Tentative Standards shall, in the future, be published in the form of a separate pamphlet and not in the Proceedings. Since the omission of the Tentative Standards from the Proceedings would be contrary to the by-laws, the Executive Committee wishes to submit to the Society at this meeting, for such action as may be taken pending the appropriate amendment of the by-laws, the question of the publication of the Tentative Standards only in the Proceedings or as a separate publication."

The following motion by Mr. J. A. Capp was carried:

> "That the Tentative Standards be published in the Proceedings as heretofore, and that the Executive Committee be requested to take such action as they see fit with regard to the separate publication of the Tentative Standards."

The report of Committee A-2 on Wrought Iron was introduced by its chairman, Mr. S. V. Hunnings. On motion of Mr. Hunnings, the following proposed tentative specifications were accepted for publication among the Tentative Standards of the Society:

Proposed Tentative Specifications for Wrought-Iron Pipe;
Proposed Tentative Specifications for Staybolt Iron;
Proposed Tentative Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars.

On motion of Mr. Hunnings, the proposed revision in the Standard Specifications for Refined Wrought-Iron Bars (A 41–13) was accepted as tentative.

The report of Committee D-9 on Electrical Insulation was presented by its chairman, Mr. C. E. Skinner. On motion of Mr. Skinner, the proposed Tentative Tests for Molded Insulating Materials were accepted for publication among the Tentative Standards of the Society.

The report of Committee E-4 on Magnification Scales for Micrographs was presented by its chairman, Mr. W. H. Bassett. On motion of Mr. Bassett, the proposed Tentative Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys were accepted for publication among the Tentative Standards of the Society.

The report of Committee E-5 on Standing Committees was presented by Mr. C. E. Skinner, vice-chairman, in the absence of the chairman, Mr. Edgar Marburg.

The report of Committee E-6 on Papers and Publications, Mr. Edgar Marburg, chairman, was, in the absence of the chairman, presented by the Assistant to the Secretary, who called attention to the fact that four committee reports containing recommendations as to standards were received too late to be printed and mailed to the membership at large four weeks in advance of the annual meeting, as prescribed by the Regulations Governing Standing Committees. On motion of the Assistant to the Secretary, the requirements of the Regulations were waived with respect to these four reports.

The tellers on the votes for election of officers presented their report, and in accordance therewith, the President announced the election of the following officers: For President, to serve for one year, Genl. W. H. Bixby; for Vice-President, to serve for two years, Edward Orton, Jr.; for Members of Executive Committee, to serve for two years, J. A. Capp, W. F. M. Goss, W. M. Kinney and C. D. Young.

The President announced that the newly elected President and Vice-President were both unable to be present at the meeting, each having been called into active service of the Government. At the request of the President, the Assistant to the Secretary read the following letters from General Bixby and Mr. Orton:

KANSAS CITY, MO., June 21, 1917.

TO THE OFFICERS AND MEMBERS OF AMERICAN SOCIETY FOR TESTING MATERIALS.

Gentlemen:

I regret exceedingly that unexpected duties under the War Department, due to war urgencies that did not exist at the time I accepted the nomination to the presidency of the Society for the next year, prevent me from being present at the June annual meeting.

This is a special disappointment to me because for some time past, the June meeting of this Society has been to me the most pleasant feature of each year.

Because of the importance of its investigations and discussions and because of the great ability and the enthusiasm and efficiency of its committees, the American Society for Testing Materials is in my opinion more useful to the United States public than any other single technical society of the country. If the Society maintains, during the coming year, the same high standard as of former years (and I feel sure that it will do so), each member of the Society will have renewed reason this year to congratulate himself on the existence of the Society and to be proud of his share in its work.

I thank you for the honor of the nomination to your Presidency (and the election, if the nomination be ratified) which you have so generously tendered me. Although I am unable to be with you at this meeting, I feel sure I shall be able to attend many and perhaps all of the subsequent meetings of the Executive Committee and of the Society during the coming year, and to do my share of their important work.

Very truly yours,

(Signed) WM. H. BIXBY,
Brig. Gen., U. S. Army, Retired

COLUMBUS, O., May 16, 1917.

MR. EDGAR MARBURG, *Secretary-Treasurer*,
American Society for Testing Materials.

Dear Mr. Marburg:

. . . I am especialy sorry that the honor of being proposed as Vice-President of the Society happens to come up at a time when I will be unable to attend the meeting, but no one could have foreseen the exact turn which matters have taken, and it was not for the best interest of the country for us to assume that what has occurred, would occur. Otherwise, I should not have permitted my name to be used at present. I beg you will understand that I am in no ways insensible to the honor that has been conferred in proposing me for this office. In case I should be elected, I hope you will make this perfectly clear to the members of the Society, and especially to its Executive Committee.

Yours very truly,
(Signed) EDWARD ORTON, JR.

The meeting then adjourned till 3 P. M.

SECOND SESSION—TUESDAY, JUNE 26, 3 P. M

On Cast Iron, Corrosion and Testing.

Mr. J. H. Gibboney in the chair.

The report of Committee A-3 on Cast Iron was presented by its chairman, Mr. Richard Moldenke. On motion of Mr. Moldenke, the proposed Tentative Specifications for Cast-Iron Soil Pipe and Fittings, and the proposed Tentative Specifications for Railroad Malleable-Iron Castings, were accepted for publication among the Tentative Standards of the Society.

On motion of Mr. Moldenke, the proposed revision of the Standard Specifications for Gray-Iron Castings (A 48–05) was accepted as tentative.

The report of Committee A-5 on Corrosion of Iron and Steel was presented by its chairman, Mr. S. S. Voorhees.

The report of Committee E-1 on Methods of Testing was then introduced by its chairman, Mr. Gaetano Lanza. On motion of Mr. Lanza, the proposed revisions of the Standard Methods of Testing (E 1–16) were accepted as tentative.

A paper on "An Alternating Torsion Testing Machine" was presented by the author, Mr. D. J. McAdam, Jr.

A paper on "Rapid Semi-Autographic Tests for Determining the Proportional Limit" by Mr. H. F. Moore was, in the absence of the author, read by title.

A paper on "Distribution of Pressures through Earth Fills" was presented by Mr. F. H. Jackson, Jr., in the absence of the author, Mr. A. T. Goldbeck, and discussed.

A paper on "Method for Studying the Effects of Temperature upon the Physical Condition of Asphalts, Waxes, etc.," under the joint authorship of Mr. J. A. Capp and Mr. F. A. Hull, was presented by Mr. Capp and discussed.

The meeting then adjourned till 8 P. M.

THIRD SESSION—TUESDAY, JUNE 26, 8 P. M.

Past-President Mansfield Merriman in the chair.

The Presidential address entitled "Our Society" was delivered by the retiring President, Mr. A. A. Stevenson.

The Chair announced that all of the living Past-Presidents of the Society were present at this session and each would be asked to say a few words in commemoration of the Fifteenth Anniversary of the incorporation of the Society; in accordance with which Past-Presidents A. W. Gibbs, Arthur N. Talbot, Robert W. Hunt, Henry M. Howe and Mansfield Merriman addressed the meeting.

The meeting then adjourned till the following morning, and was followed by an informal reception to members, ladies and guests.

FOURTH SESSION—WEDNESDAY, JUNE 27, 10 A. M.

On Steel and Iron.

President A. A. Stevenson in the chair.

The report of Committee A-1 on Steel was presented by its chairman, Mr. C. D. Young. Mr. Young reported that at a meeting held Monday evening, June 25, the committee had amended its report by proposing tentative revisions[1] (in addition to those already proposed in the report) in the following specifications:

Standard Specifications:

For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52–15);
For Welded Steel and Wrought-Iron Pipe (A 52–15);
For Boiler and Firebox Steel for Locomotives (A 30–16).

Tentative Specifications:

For Boiler and Firebox Steel for Stationary Service (A 70–16 T).

The amendments to the report also included proposed tentative revisions[1] in the Standard Specifications for Carbon-Steel Car and Tender Axles (A 21–14), embodying new requirements for the drop test of car axles.

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[1] These revisions appear in detail in an Addendum to the report of Committee A-1, pp. 119–120.

On motion of Mr. Young, the proposed revisions in the following specifications were accepted as tentative:

For Blooms, Billets and Slabs for Carbon-Steel Forgings (A 17–13);
For Carbon-Steel and Alloy-Steel Forgings (A 18–16);
For Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19–16);
For Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 63–16);
For Carbon-Steel Car and Tender Axles (A 21–14);
For Lap-Welded and Seamless Steel Boiler Tubes, etc., for Locomotives (A 28–16);
For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52–15);
For Welded Steel and Wrought-Iron Pipe (A 53–15)·
For Automobile Carbon and Alloy Steels (A 29–16);
For Boiler and Firebox Steel for Locomotives (A 30–16).

Mr. Young moved that the proposed revised Tentative Specifications for Steel Tie Plates be accepted for publication among the Tentative Standards of the Society. Capt. Robert W. Hunt offered an amendment that these specifications be referred back to the committee.

The vote on this amendment was lost and Mr. Young's original motion was carried.

On motion of Mr. Young, the proposed revisions in the Tentative Specifications for Boiler and Firebox Steel for Stationary Service (A 70–16 T) were accepted, and the specifications continued as tentative for another year.

On motion of Mr. Young, the proposed Tentative Specifications for Carbon Tool Steel were accepted for publication among the Tentative Standards of the Society.

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[1] These revisions appear in detail in an Addendum to the report of Committee A-1, pp. 118–119.

The report of Committee A-4 on Heat Treatment of Iron and Steel, Mr. A. Sauveur, chairman, was presented by the Assistant to the Secretary, in the absence of the chairman. This report contained recommendations of Committee A-4 in reply to two questions submitted by Committee A-1 on Steel. It developed in the discussion of the report that Committee A-1 did not feel that these recommendations could be considered as satisfactory replies to its questions, and on motion the report was referred back to the committee for further consideration.

The report of Committee E-3 on Revision of Pipe Threads was presented by Mr. J. A. Hance in the absence of the chairman, Mr. H. V. Wille. The report was accepted for publication in the Proceedings, provided that a subsequent letter ballot of Committee E-3 should approve the report without a dissenting vote, the report not having previously been submitted to letter ballot of the committee as required by the Regulations Governing Standing Committees.[1]

The following papers were then presented by their authors and discussed:

"Some Applications of Magnetic Analysis to the Study of Steel Products," by Mr. Charles W. Burrows;

"Annealing Temperatures and Grain Growth," by Mr. D. J. McAdam, Jr.

A topical discussion on "The Rôle of the Several Alloying Elements in the Alloy Steels" was formally opened by the following speakers:

The Rôle of Manganese, by Mr. Henry M. Howe;
The Rôle of Nickel, by Mr. R. R. Abbott;
The Rôle of Silicon, by Mr. W. E. Ruder;
The Rôle of Vanadium, by Mr. G. L. Norris;
The Rôle of Chrome-Vanadium, by Mr. F. J. Griffiths.

The discussion was then thrown open to the meeting.

The meeting then adjourned till 8 P. M.

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[1] The subsequent vote by letter ballot of Committee E-3 was affirmative without a dissenting vote, and the report is therefore printed in the Proceedings, pp. 504–507.

FIFTH SESSION—WEDNESDAY, JUNE 27, 8 P. M.

On Non-Ferrous Metals.

Mr. J. A. Capp in the chair.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by its chairman, Mr. Wm. Campbell. On motion of Mr. Campbell, the following proposed tentative specifications were accepted for publication among the Tentative Standards of the Society:

Proposed Tentative Specifications for Spelter;
Proposed Tentative Specifications for Brass Forging Rod;
Proposed Tentative Specifications for Free-Cutting Brass Rod for Use in Screw Machines;
Proposed Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings and Finished Car and Tender Bearings.

On motion of Mr. Campbell, the Tentative Specifications for Seamless Brass Boiler Tubes (B 14–16 T)[1] were amended by the insertion at the end of Section 3 on "Chemical Composition" of the words: "zinc.....remainder."

On motion of Mr. Campbell, the proposed Methods for Analysis of the Alloys of Lead, Tin, Antimony and Copper, were accepted for publication among the Tentative Standards of the Society, provided that a subsequent letter ballot of Committee B-2 on these proposed methods should be carried without a dissenting vote, this item not having previously been submitted to letter ballot of the committee as required by the Regulations Governing Standing Committees.[2]

The Chair then read a telegram from the Secretary-Treasurer, Mr. Edgar Marburg, as follows:

> "In reply to your telegram of yesterday, kindly convey to the Society in meeting assembled my deep-felt appreciation of its good wishes. The success of the current meeting is a splendid tribute to those upon whom the added burdens from my enforced absence have suddenly fallen."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, pp. 448–451 (1916).

[2] The subsequent vote by letter ballot of Committee B-2 was affirmative without a dissenting vote, and the Tentative Methods are therefore printed in these Proceedings, pp. 622–629.

A paper on "Testing of Sheet Brass," by Mr. C. H. Davis, was then introduced by the author and discussed.

A paper on "Inspection of Brass and Bronze," by Mr. Alfred D. Flinn and Mr. Ernst Jonson, was presented by Mr. Flinn and discussed.

The following papers were then presented by their respective authors and discussed:

"Light versus Heavy Reductions in Cold Working Brass," by Mr. W. Reuben Webster;

"Hardness of Hard-Drawn Copper," by Mr. E. H. Peirce;

"Electrolytic Determination of Tin on Tinned Copper Wire," by Mr. George G. Grower.

Owing to the lateness of the hour, a paper on "Interior Surface Defects on Brass Condenser Tubes as a Cause of Corrosion," by Mr. W. Reuben Webster, was read by title.

The meeting then adjourned till the following morning.

SIXTH SESSION—THURSDAY, JUNE 28, 10 A. M.

On Preservative Coatings and Miscellaneous Materials.

Vice-President S. S. Voorhees in the chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by its chairman, Mr. P. H. Walker. Mr. Walker reported that certain minor revisions[1] in the following methods had been adopted at a meeting of the committee held on Wednesday, June 27:

Methods for Routine Analysis of White Pigments;
Methods for Routine Analysis of Dry Red Lead.

On motion of Mr. Walker, the recommendation of the committee that the following proposed standards (at present tentative) be submitted to letter ballot of the Society for adoption as standard, was unanimously approved:

Tentative Method for Routine Analysis of White Pigments[2] (as amended);

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[1] These revisions appear in detail in an Addendum to the report of Committee D-1, p. 460.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 536 (1916).

Tentative Tests for Paint Thinners other than Turpentine[1];
Tentative Tests for Shellac.[2]

On motion of Mr. Walker, the following methods were accepted for publication among the Tentative Standards of the Society:

Method for Routine Analysis of Dry Red Lead (as amended);
Method for Routine Analysis of Yellow, Orange, Red and Brown Pigments containing Iron and Manganese.

A paper on "Metal Primer Tests" was presented by the author, Mr. H. A. Gardner, and discussed.

The report of Committee D-2 on Lubricants was presented by Mr. P. H. Conradson, vice-chairman, in the absence of the chairman, Mr. C. P. Van Gundy. On motion of Mr. Conradson, the proposed Tentative Tests for Lubricants were accepted for publication among the Tentative Standards of the Society.

A paper on "Determination of Absolute Viscosity by the Saybolt Universal and Engler Viscosimeters," was introduced by the author, Mr. Winslow H. Herschel, and discussed.

The report of Committee D-4 on Road Materials, Mr. L. W. Page, chairman, was, in the absence of the chairman, presented by Mr. Prévost Hubbard, secretary. On motion of Mr. Hubbard, the following proposed tests and definitions were accepted for publication among the Tentative Standards of the Society:

Proposed Tentative Test for Toughness of Rock;
Proposed Revised Tentative Test for Determination of Apparent Specific Gravity of Coarse Aggregates;
Proposed Tentative Definitions of "Aggregate," "Gravel," "Screen" and "Sieve."

On motion of Mr. Hubbard, the proposed revisions of the Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment (D 20–16) were accepted as tentative.

A paper on "Effect of Controllable Variables on the Toughness Test for Rock" was then presented by the author, Mr. F. H. Jackson, Jr., and discussed.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 518 (1916).

[2] *Ibid*, p. 522.

A paper on "A New Consistency Tester for Viscous Liquid Bituminous Materials," under the joint authorship of Mr. Prévost Hubbard and Mr. F. P. Pritchard, was presented by Mr. Hubbard and discussed.

A paper on "Optical Properties and Theory of Color of Pigments and Paints" was introduced by the author, Mr. H. E. Merwin, and discussed.

The meeting then adjourned till 8 P. M.

SEVENTH SESSION—THURSDAY, JUNE 28, 8 P. M.

On Cement and Concrete.

Mr. F. W. Kelly in the chair.

The report of Committee C-1 on Cement was presented by its chairman, Mr. R. S. Greenman.

A paper on "Properties of Cement-Lime-Sand Mortars" was presented by the author, Mr. Warren E. Emley.

The following papers were then read by title, in the absence of the authors, and discussed:

"High-Silica Portland Cement," by Mr. A. W. K. Billings;

"Economical Proportions for Portland-Cement Mortars and Concretes," by Mr. J. A. Kitts.

The following papers were then introduced by their respective authors and discussed:

"Effect of Rate of Application of Load on the Compressive Strength of Concrete," by D. A. Abrams;

"Tests of Concrete Slabs to Determine the Effect of Removing Excess Water Used in Mixing," by Mr. A. N. Johnson.

The meeting then adjourned till the following morning.

On the invitation of the Chair, Mr. Edw. D. Boyer, chairman of the Golf Tournament Committee, awarded the following prizes as a result of the Tournament held Thursday afternoon:

For Low Score for the Course:

The American Society for Testing Materials Championship Cup and a medal: Mr. H. F. Jefferson, Pittsburgh, Pa.

For the Lowest Net Score:

First Prize.......Mr. Wm. B. Price, Waterbury, Conn.
Second Prize.....Mr. J. L. Miner, New York City.
Third Prize......Mr. A. S. Hook, Chicago.

For the winner of the "Blind Handicap:"

A silver cup.....Mr. C. L. Sullivan, Dayton, O.

EIGHTH SESSION—FRIDAY, JUNE 29, 10 A. M.

On Concrete and Lime.

Mr. W. K. Hatt in the chair.

The report of Committee C-2 on Reinforced Concrete, Mr. F. E. Turneaure, chairman, was, in the absence of the chairman, presented by the secretary, Mr. Richard L. Humphrey. The Assistant to the Secretary then presented two written discussions, after which Mr. Humphrey moved that the report of the committee be received for publication in the Proceedings.

Mr. R. J. Wig then discussed the report, and moved an amendment to the original motion, that Chapters II–VI, inclusive, of the report of the Joint Committee on Concrete and Reinforced Concrete be referred back to Committee C-2, and that such portions of these chapters as are now under consideration by other committees of the Society be referred to such committees for their consideration.

After considerable discussion, this amendment was lost. Mr. Humphrey's original motion was then carried.

Mr. A. N. Talbot moved that Mr. Wig be requested to add to his discussion information as to the methods of making concrete to avoid the troubles to which he referred in his discussion of the report of the Joint Committee. This motion was seconded and carried.

The report of Committee C-9 on Concrete and Concrete Aggregates was then presented by its chairman, Mr. Sanford E. Thompson, who reported certain minor revisions.

The report of Committee C-7 on Lime was introduced by its chairman, Mr. James S. Macgregor. On motion of Mr. Macgregor, the proposed Tentative Specifications for Masons' Hydrated Lime were accepted for publication among the Tentative Standards of the Society.

A paper on "Tests of Concrete Road Aggregates" was presented by the author, Mr. J. P. Nash, and discussed.

A paper on "Apparent Specific Gravity of Non-Homogeneous Fine Aggregates," by Mr. A. S. Rea, was read by title in the absence of the author.

The following papers were then presented by their respective authors and discussed:

"Effects of Grading of Sands and Consistency of Mix upon the Strength of Plain and Reinforced Concrete," by Mr. L. N. Edwards;

"Comparison of the Heat-Insulating Properties of Materials Used in Fire-Resistive Construction," by Mr. W. A. Hull.

The meeting then adjourned till 3 P. M.

NINTH SESSION—FRIDAY, JUNE 29, 3 P. M.

On Ceramics.

Past-President A. N. Talbot in the chair.

The report of Committee C-4 on Clay and Cement Sewer Pipe was presented by its chairman, Mr. Rudolph Hering, who called attention to a number of revisions in the report which had been agreed upon at a meeting of the committee held on the previous day. On motion of Mr. Hering the following proposed tentative specifications and recommended practice, as amended, were accepted for publication among the Tentative Standards of the Society:

Proposed Tentative Specifications for Clay Sewer Pipe;
Proposed Tentative Specifications for Cement-Concrete Sewer Pipe;
Proposed Revised Tentative Recommended Practice for Laying Sewer Pipe;
Proposed Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling.

The committee reported that it had submitted to a letter ballot the question of combining the proposed Tentative Specifications for Clay and Cement-Concrete Sewer Pipe into one specification instead of two as now printed, with the following result: affirmative, 8; negative, 6; not voting, 6.

The report of Committee C-6 on Drain Tile was presented by the chairman, Mr. A. Marston.

A paper on "Failure of a 30-in. Tile Drain at Albert Lea, Minnesota," was presented by the author, Mr. R. W. Crum, and discussed.

The report of Committee C-8 on Refractories was presented by its chairman, Mr. A. V. Bleininger. On motion of Mr. Bleininger, the following proposed methods and tests were accepted for publication among the Tentative Standards of the Society:

Proposed Tentative Methods for Ultimate Chemical Analysis of Refractory Materials;
Proposed Tentative Test for Refractory Materials under Load at High Temperatures;
Proposed Tentative Test for Slagging Action of Refractory Materials.

A paper on "Suggested Improvements in the Manufacture of Silica Brick," under the joint authorship of Mr. C. E. Nesbitt and Mr. M. L. Bell, was presented by Mr. Nesbitt and discussed.

The report of Committee C-10 on Hollow Building Tile was presented by Mr. J. H. Griffith in the absence of the chairman, Mr. L. H. Provine.

Mr. Henry S. Spackman then introduced the following resolution which was on motion adopted:

"*Resolved,* That it is the sense of the members present at this meeting that the Executive Committee be requested to give consideration to the general subject of the formation of and methods of procedure to be followed by joint committees and the publication of joint reports; whether these joint committees be made up from various committees of this Society or of representatives of this Society and other societies and organizations."

The meeting then adjourned till 8 P. M.

TENTH SESSION—FRIDAY, JUNE 29, 8 P. M.

On Miscellaneous Materials.

President A. A. Stevenson in the chair.

The report of Committee C-5 on Fireproofing, Mr. Ira H. Woolson, chairman, was, in the absence of the chairman, presented by Mr. James S. Macgregor and discussed. On motion of Mr. Macgregor, the proposed revisions of the Standard Test for Fireproof Floor Construction (C 2–08) and the Standard Test for Fireproof Partition Construction (C 3–09) were accepted as tentative.[1]

The report of Committee D-8 on Waterproofing, Mr. W. A. Aiken, chairman, was, in the absence of the chairman, presented by Mr. L. W. Walter, vice-chairman. Mr. Walter moved that the following proposed tentative specifications be accepted for publication among the Tentative Standards of the Society:

Proposed Tentative Specifications for Asphalt for Waterproofing;

Proposed Tentative Specifications for Primer for Use with Asphalt for Waterproofing;

Proposed Tentative Specifications for Coal-Tar Pitch for Waterproofing;

Proposed Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Waterproofing.

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[1] Subsequent to the annual meeting, it developed that Committee C-5 had intended that certain of the proposed revisions here referred to should also be published separately as a tentative standard. Accordingly, the Tentative Method for Control of Fire Tests and Classification of Materials and Construction as Determined by Test has been included among the Tentative Standards of the Society, pp. 679–680.—ED.

Mr. E. W. DeKnight moved to amend this motion by substituting the word "damp-proofing" for the word "waterproofing" in the title of the first specification. After considerable discussion, this amendment was withdrawn in favor of an amendment by Mr. Walter to substitute for the word "waterproofing" in the titles of each of the specifications, the words "use in damp-proofing and waterproofing." The original motion, as amended, was then carried.

The report of Committee D-11 on Rubber Products was then introduced by its chairman, Mr. Edw. A. Barrier. On motion of Mr. C. B. Martin, the proposed Tentative Specifications for Air-Line Hose for Pneumatic Tools were accepted for publication among the Tentative Standards of the Society.

The report of Committee D-7 on Timber, Mr. Hermann von Schrenk, chairman, was, in the absence of the chairman, presented by the Assistant to the Secretary. Mr. J. A. Newlin moved that the proposed Tentative Specifications for Wooden Paving Blocks be accepted for publication among the Tentative Standards of the Society.

Mr. W. H. Fulweiler, after presenting a written discussion on these specifications, moved an amendment to the original motion that Sections 7 to 9 inclusive, dealing with "Preservatives," be referred back to the committee. Mr. Fulweiler in his discussion having made the statement that since these specifications had been prepared by a sub-committee which was not constituted in accordance with the Regulations Governing Standing Committees, they were therefore illegal, the Chair pointed out that the specifications, strictly speaking, were not illegal but simply irregular, and that the regulation in question could be waived by the Society in meeting if it so desired. The original motion as amended was held in abeyance to consider a motion by Mr. C. M. Taylor to waive, in this instance, the requirement of the Regulations Governing Standing Committees that "sub-committees on proposed complete standard specifications for materials shall consist of not fewer than six members, and at least one-half of the membership shall be composed of non-producers." This motion was lost by a vote of 7 affirmative and 8 negative; in pursuance of which, the Chair ruled that the proposed Tentative Specifications for Wooden

Paving Blocks could not be considered at this meeting, and that they were referred back to the committee.

Mr. S. R. Church moved that the Committee be permitted to include, in the proposed Standard Methods for Sampling and Analysis of Creosote Oil, Method (*A*) on Water and Method (*E*) on Specific Gravity of Fractions, the motion requiring a nine-tenths affirmative vote of those voting, since these two methods had not previously been published as tentative. This motion was carried by unanimous vote.

Mr. Church then moved that the proposed Standard Methods for Sampling and Analysis of Creosote Oil, including methods (*A*) and (*E*), be referred to letter ballot of the Society for adoption as standard. Mr. J. S. Miller, Jr., offered an amendment to this motion, that the title of these Methods be changed by substituting for the words "creosote oil," the words "preservative oils."

This amendment was lost and the original motion was then carried.

On motion of Mr. Church, the proposed Tentative Methods for Analysis of Creosote Oil, comprising Method (*F*) for Float Test of Residue, and Method (*G*) for Coke Residue, were accepted for publication among the Tentative Standards of the Society.

The report of Committee D-10 on Shipping Containers, was presented by Capt. G. E. Carleton in the absence of the chairman, Col. B. W. Dunn. On motion of Captain Carleton, the proposed Tentative Specifications for Canned Foods Boxes, Nailed and Lock-Corner Construction, and the proposed Tentative Specifications for Canned Foods Boxes, Wirebound Construction, were accepted for publication among the Tentative Standards of the Society.

The report of Committee D-13 on Textile Materials, Mr. Wm. D. Hartshorne, chairman, was, in the absence of the chairman, presented by the Assistant to the Secretary.

A vote of thanks to the management of the Hotel Traymore for the excellent facilities provided for the meetings and the courteous attention at all times, was unanimously carried.

On motion of Mr. Thomas Nolan, a vote of thanks to the retiring officers for their efficient work in the conduct of the meetings, was unanimously carried.

The Chair then declared the meeting adjourned *sine die.*

APPENDIX.

MEMBERS PRESENT OR REPRESENTED.

A

- Abbott, Robert R.
- Abrams, D. A.
- Ackerman, Ernest R.
- Aertsen, G.
- Affleck, B. F.
- Allentown Portland Cement Co.,
  - R. S. Weaver.
- American Brass Co.,
  - W. H. Bassett.
- American Bridge Co.,
  - Emil Larsson.
- American Foundrymen's Association,
  - A. O. Backert.
- American Institute of Architects,
  - Thomas Nolan.
- American Locomotive Co.,
  - E. J. Edwards.
- American Smelting and Refining Co.,
  - Chas. Mindeleff.
- American Steel and Wire Co.,
  - S. M. Rodgers.
- American Zinc, Lead and Smelting Co.,
  - H. A. Wentworth.
- Amies Road Co.,
  - W. T. Newcomb.
- Ammon, Mark A.
- Ashby, E. B.
- Ashton, Ernest.
- Associated Metal Lath Manufacturers,
  - Z. W. Carter.
- Aston, James.
- Atlantic Refining Co.,
  - F. C. Robinson.
- Aupperle, James A.

B

- Babcock, Guilford C.
- Backert, A. O.
- Bacon, Charles V.
- Baldwin Locomotive Works,
  - J. A. Hance.
- Balz, George A.
- Barber Asphalt Paving Co.,
  - J. S. Miller, Jr.
- Barrett Co., The
  - Wm. S. Babcock.
- Barron, E. T.
- Bartlett, Geo. S.
- Bartlett, Henry.
- Bates, P. H.
- Beall, F. F.
  - W. C. Peterson.
- Bemis Bro. Bag Co.,
  - A. H. Clarke.
- Berry, H. C.
- Bethlehem Steel Co.,
  - E. O'C. Acker.
- Bird, R. M.
- Bitting, A. W.
- Blackmer, L. G.
- Blair, W. P.
- Blakeley, Abraham G.
- Blanchard, Arthur H.
- Bleininger, A. V.
- Boardman, J. W., Jr.
- Boeck, P. A.
- Boonton Rubber Manufacturing Co.,
  - R. W. Seabury.
- Boyd, Jas. K.
- Boyer, E. D.
- Boyle, John D.
- Boynton, H. C.
- Bridgeport Brass Co.,
  - A. A. Baldwin.
- Brooks, Benjamin.
- Brown, C. G.
- Brunner, John.
- Buck, D. M.
- Buell, W. H.
- Buffalo, Rochester & Pittsburgh R. R. Co.,
  - Frank Henry.
- Bureau of Construction and Repair, U. S. N.,
  - E. L. Lasier.
- Bureau of Steam Engineering, U. S. N.,
  - D. J. McAdam, Jr.
- Burrows, Chas. W.
- Byers Co., A. M.
  - James Aston.

C

- Cain, J. R.
- Calumet Steel Co.,
  - A. S. Hook.

Cambria Steel Co.,
  G. E. Thackray.
Camden Forge Co.,
  G. N. Losee.
Camp, A. D.
Campbell, Wm.
Canby, W. P.
Capp, J. A.
Carbolineum Wood Preserving Co.,
  E. F. Paddock.
Carleton, G. E.
Carnahan, R. B.
Carnegie Steel Co.,
  J. O. Leech.
Carroll, A. W.
Cavender, John H.
Central Foundry Co.,
  H. Y. Carson.
Central Iron and Steel Co.,
  Robt. H. Irons.
Charls, G. H.
Cheesman, Frank P.
Christie, A. J.
Church, S. R.
Churchill, Chas. S.
Claiborne, Chas. H.
Cobb, E. B.
Coleman, R. E.
Colonial Steel Co.,
  N. B. Hoffman.
Columbia Steel and Shafting Co.,
  E. T. Ickes.
Concrete Products Co. of Pittsburgh,
  J. D. Lambie.
Conn, Charles F.
Connolly, John O.
Connolly, R. D.
Conradson, P. H.
Conroy, L. W.
Consolidated Rosendale Cement Co.,
  Wm. C. Morton.
Constant Co., C. L.,
  J. C. McGrew.
Cooke, G. W.
Cooper, Wm. A.
Cowan, Wm. A.
Coyle, Francis B.
Crandell, John S.
Crawford, C. H.
Crawford. J. C.
Crescent Portland Cement Co.,
  O. C. Hasse.
Cromwell, O. C.
Crowe, J. J.
Crum, R. W.
Crume, W. H.
Cummings, Robert A.

D

Davies, George C.
De Armond, F. L.
De Forest, Alfred V.
De Knight, Edward W.
Department of Wharves, Docks and
    Ferries, Philadelphia,
  G. S. Webster.
Detroit-Edison Co.,
  Albert E. White.
Devries, R. P.
Diller, H. E.
Disston and Sons, Henry,
  Wm. D. Mainwaring.
Dow, Allan W.
Drew, Harry.
Dudley, P. H.
  C. B. Bronson.
Dunbar, W. O.
Dunn, Wm. R.
Duquesne Slag and Products Co.,
  W. D. Brewer.

E

Eagle-Picher Lead Co.,
  J. A. Schaeffer.
Ecolé Polytechnique Library,
  Joseph Haynes.
Eddy, Harrison P.
Edgerly, D. W.
Edwards, E. J.
Edwards, Llewellyn N.
Ellinwood, G. H.
Elliot, George K.
Emley, Warren E.
Engineering News-Record,
  E. J. Mehren.
Epstein, H. M.
Erie Forge Co.,
  G. W. J. Stout.
Esau, G. Walter.

F

Fahy, Frank P.
Faragher, W. F.
Farran, Wm. J.
Fay, Henry.
Fay, Spofford and Thorndike,
  Henry Fay.
Fead, Tsoong Fang.
Felton, G. E.
Ferguson, Lewis R.
Firestone Tire and Rubber Co.,
  J. W. Cooper.
Fitch, Roy O.
Flagg, Stanley G., Jr.
Fleming, Wm. R.

Flinn, Alfred D.
Flowers, A. E.
Force, H. J.
Forrest, C. N.
Fort, E. J.
Foss, Fred E.
Franklin Steel Co.,
    E. E. Hughes.
French, J. Hansell.
Fritch, G. M.
Froehling and Robertson,
    H. C. Froehling.
Fry, Lawford H.

G

Gage, Roscoe M.
Gaines, Richard H.
Gardner, H. A.
Gates, J. S.
General Electric Co. (Schenectady),
    J. A. Capp.
General Electric Co., Lynn Works,
    J. M. Darke.
General Electric Co., Pittsfield Works,
    A. McK. Gifford.
Geological Survey of New Jersey,
    R. B. Gage.
Gibboney, Jas. H.
Gibbs, A. W.
Glasgow Iron Co.,
    J. P. Roe.
Goldstein, H. I.
Goodell, John M.
Goodspeed, G. M.
Goodyear Tire and Rubber Co.,
    E. H. Barnwell.
Goss, W. F. M.
Green, John L.
Greene, Hermann L.
Greenman, Russell S.
Gregory, E. D.
Griffith, E. D.
Griffith, John H.
Griffith, R. E.
Griffiths, Frederick J.
Gulick, Henry, Jr.
    Gearhart, J. A.
Gundlach, H. R.
Gypsum Industries Association,
    S. G. Webb.

H

Hagy Waste Works,
    R. L. Hays.
Harding, Wm. H.
Harriman, N. F.
Harrington, C. O., Jr.
Hartford Steam Boiler Inspection and Insurance Co.,
    Wm. J. Farran.
Hartshorne, Wm. D.
Hartwell, S. W.
Hartzell, H. S.
Hatt, W. K.
Hawk, Lester C.
Hay, J. T.
Hayward, Oscar C.
Headley Good Roads Co.,
    D. J. McSwiney.
Heckel, G. B.
Henry, J. A.
Hering, Rudolph.
Herschel Winslow H.
Hewitt Rubber Co.,
    W. S. Kimley
Hibbs, M. E.
Hicks, T. A.
Hill, Joseph C.
Holstein, L. S.
Holz, Herman A.
Hough, Norman G.
Howe, Henry M.
Hubbard, Prévost.
Hull, Walter A.
Humphrey, Richard L.
Humpton, Wm. G.
Hunt and Co., R. W.,
    R. W. Hunt.

I

Ickes, E. T.
Illinois Steel Co.,
    P. E. Carhart.
Illinois Steel Co., Warehouse Dept.,
    H. N. Copthorne.
Imperial Varnish and Color Co.,
    H. Mc Ewen.
Ingalls, F. P.
Inspection Dept., Assoc. Factory Mutual Fire Ins. Co.,
    E. A. Barrier.
Interocean Oil Co.,
    Leroy M. Law.
Iron Age, The,
    W. W. Macon.

J

Jackson, Frank H., Jr.
Jaquith, Horace J.
Jaros, Isidore.
Jarvis, Ernest G.
Jeffers, John M.
Jefferson, H. F.
Jennings, R. E.

Jennison, H. C.
Job, Robert.
Johnson, A. N.
Johnson, George T.
Johnson, Nathan C.
Johnson, Reeves K.
Johnston, John.
Jones, Jesse Lee.
Jones and Laughlin Steel Co.,
    J. J. Shuman.

K

Kaiser, Frank H.
Kelley, F. W.
Kelley Island Lime and Transport Co.,
    Henry Angel.
Kellogg, James W.
Kenney, E. F.
Kenney, L. H.
Kerr, C. H.
Kershaw, Wm. H.
Kier, P. S.
Kinney, Wm. M.
Kirkpatrick, F. A.
Klein, W. H.
Klotz, J. R. M.
Knisely, Edward.
Koch, George B.
Krebs Pigment and Chemical Co.,
    A. S. Krebs.
Kurtz, Thos. N.

L

Lackawanna Steel Co.,
    F. E. Abbott.
Laclede-Christy Clay Products Co.,
    J. L. Green.
Lane and Co., J. H.,
    C. B. Finckel.
Lanza, Gaetano.
Larsson, Emil.
Lasier, E. L.
Lawson, T. R.
Lee Tire and Rubber Co.,
    E. E. Dearth.
Leech, J. O.
Leeds and Northrup Co.,
    C. R. Cary.
Lehigh Valley R. R.,
    S. E. Printz.
Lenhardt, James M.
Lesh, I. B.
Lesley, Robert W.
Lewis Institute,
    D. A. Abrams.
Lindsay, Charles F.
Lindsay, R. W.
Little, A. D., Inc.,
    H. J. Skinner.
Lober, John B.
Lober, W. D.
Love, H. J.
Lucas and Co., John,
    L. P. Nemzek.
Luke, C. H.
Lukens Iron and Steel Co.,
    W. G. Humpton.
Lumen Bearing Co.,
    N. K. B. Patch.
Lunn, Charles A.
Lynch, T. D.

M

MacFarland, H. B.
Macgregor, James S.
MacGregor, John R.
Mackenzie, K. G.
MacPherran, R. S.
Maitland, Harold T.
Mallory, W. S.
Manhasset Manufacturing Co.,
    H. T. Viall, Jr.
Marble, Edwin H.
Mattimore, H. S.
Marquette Cement Manufacturing Co.,
    T. G. Dickinson.
Marsh, C. P.
Marston, A.
Mastic Bond Co., Inc.,
    S. G. Webb.
Masury and Son, John W.,
    F. P. Ingalls.
Mathias, D. L.
Maywold, Frederick J.
McDonnell, M. E.
McIntyre, W. A.
McKenna, Chas. F.
McNaugher, D. W.
McNiff, G. P.
McNulty, Bernard W.
Merica, Paul D.
Meritas Mills Co.,
    J. T. Broadbent.
Meriwether, Coleman.
Merriman, Mansfield.
Midvale Steel Co.,
    G. Aertsen.
Miller, J. S., Jr.
Millwood, J. P.
Miner, Joshua L.
Mohr, Chas. T.
Moldenke, Richard.
Moller, Kenneth.
Montgomery, Robert J.

Moyer, Albert.
Murphy, Louis E.
Myers, J. E.

N

Nash, James P.
Nashville, Chattanooga and St. Louis R. R. Co.,
    C. H. Crawford.
National Tube Co.,
    F. W. Speller.
Neale, L. I.
Nelson, John H.
New Jersey Zinc Co.,
    W. H. Hendrick.
New York Central R. R. Co.,
    A. W. Carpenter.
Newberry, S. B.
Newlin, J. A.
Nicholas, I. A.
Nielsen, Reider.
Morris, G. L.
Norton Co.,
    Ross C. Purdy.

O

Okonite Co., The,
    J. P. Millwood.
Olsen, Tinius.
Olson, Louis W.
Orton, Edward ,Jr.,
    E. P. Ogden.
Otis Elevator Co.,
    M. P. Davis.

P

Page, L. W.
Patton Paint Co.,
    G. D. White.
Paul, C. E.
Pease, Burton H.
Peerless Drawn Steel Co.,
    J. M. Ormsbee.
Peirce, Edwin H.
Perrine, Harold.
Phoenix Portland Cement Co.,
    L. C. Morton.
Pickard, Glenn H.
Pittsburgh Testing Laboratory,
    J. L. Miner.
Polushkin, E. P.
Porter, J. Madison.
Portland Cement Association,
    J. P. Beck.
Potter, N. S.
Potts, Stephen C.
Pressell, George W.
Price, Wm. B.
Provost, A. J., Jr.

Q

Quimby, Henry H.

R

Racine Rubber Co.,
    H. B. Underwood.
Ramage, J. C.
Ramsay, John D.
Randall, Thos. A.
Rankin, G. A.
Raritan Copper Works,
    A. W. Carroll.
Rawdon, Henry S.
Reading Iron Co.,
    George Schuhmann.
Reinecke, L.
Reinhardt, G. A.
Remington Arms and Ammunition Co.,
    N. A. Chase.
Reninger Henry A.
Republic Iron and Steel Co.,
    L. B. Grindlay.
Rhode Island Tool Co.,
    C. B. Sadtler.
Rice, Wayland W.
Richardson, Clifford.
Riehle, Frederick A.
Rinald, C. D.
Robbins, C. W.
Roebling's Sons Co., J. A.,
    H. C. Boynton.
Rogers, Allen.
Rogers, R. E.
Rossi, L. M.
Royle and Sons, John,
    V. E. Royle.

S

Sabin, A. H.
Schaeffer, John A.
Schmid, M. H.
Schmitt, F. E.
Schueler, J. L.
Scofield, H. H.
Scott and Co., Henry L.,
    Henry L. Scott.
Seaton, Max Y.
Security Cement and Lime Co.,
    J. J. Porter.
Seely, Ray.
Sharples, Phillip P.
Shelley, H. G.
Shimer, W. R.
Shuman, Jesse J.
Skinner, C. E.
Skinner, H. J.

Slater, W. A.
Slocum, Frank S.
Smith, Francis P.
Smith, H. E.
Smith, J. Hammond.
Snow, J. P.
Somerset Rubber Reclaiming Works,
    C. B. Clark.
Souther Engineering Corporation,
    J. A. Newlands.
Spackman Engineering Co., H. S.,
    H. S. Spackman.
Spencer, Herbert.
Splitdorf Electrical Co.,
    J. L. Leibing.
Stafford, S. G.
Stalknecht, A. C.
Standard Oil Cloth Co.
    P. A. Bivins.
Standard Steel Works Co.,
    A. A. Stevenson.
Stapleton, E. R.
Starr, John J.
Steel Company of Canada,
    J. S. Morrow.
Steuer, B.
Stevenson, A. A.
Stone, George C.
Stowe, C. B.
Strehan, George E.
Sullivan, Charles L.

T

Tagge, A. C.
Tagliabue, C. J.
Talbot, Arthur N.
Taylor, Arthur P.
Taylor, C. M.
Taylor, H. G.
Taylor Instrument Cos.,
    E. N. Hurlburt.
Tefft, George H.
Thomas, I. B.
Thompson, Gustave W.
Thompson, Sanford E.
Tidewater Portland Cement Co.,
    E. R. Stapleton.
Tiemann, Hugh P.
Titanium Alloy Manufacturing Co.,
    A. C. Olfs.
Touceda, Enrique.
Trautwine, J. C., Jr.
Tretch, Wm. J.
Trist, N. B.
Turner, Henry C.
Turner Co., J. Spencer
    C. S. Cook.

U

Uhler, J. Floyd.
Unger, J. S.
Union Drawn Steel Co.,
    L. W. Williams.
United and Globe Rubber Manufacturing Cos.,
    G. W. Skirm.
United Gas Improvement Co.,
    W. H. Fulweiler.
United States Gutta Percha Paint Co.,
    W. W. Rice.
United States Gypsum Co.,
    V. G. Marani.
United States Metals Refining Co. (Chrome),
    R. W. Deacon.
United States Metals Refining Co. (New York),
    F. F. Colcord.
United States Rubber Co.,
    A. A. Somerville.
United States Sherardizing Co.,
    C. J. Kirk.
Universal Portland Cement Co.,
    B. F. Affleck.

V

Vacuum Oil Co.,
    F. R. Baxter.
Vassar, H. S.
Vial, F. K.
Victor Talking Machine Co.,
    E. F. Hicks.
Voorhees, S. S.

W

Waclark Wire Co.,
    R. T. Roberts.
Wagner, Samuel T.
Walker, Percy H.
Walter, L. W.
Waring, F. M.
Warner, Charles.
Warner-Quinlan Asphalt Co.,
    Wm. C. Monsell.
Warren, J. B.
Warwick, C. Laurence.
Washburn, Willis F.
Washington Steel and Ordinance Co.,
    S. V. Hunnings.
Watts, Arthur S.
Weaver, R. S.
Webbert, L. P.
Webster, George S.
Webster, W. Reuben.

Weinfurtner, E. M.
Weiss, John Morris.
Western Electric Co.,
  C. W. Robbins.
Westinghouse Air Brake Co.,
  H. C. Loudenbeck.
Westinghouse Church Kerr Co.,
  C. M. Chapman.
Westinghouse Electric and Manufacturing Co.,
  T. D. Lynch.
Weymouth, F. A.
White, Albert E.
White, G. D.
Whittier, Elmer S.
Wickhorst, M. H.
Wig, R. J.
Wight, Frank C.
Wiley, W. O.
Williams, L. W.
Wilson, Percy H.
Wiltsee, W. P.
Winkler, L. H.
Wood, Harold F.
Wood, Walter.
Wood, Iron and Steel Co.,
  W. A. Cooper.
Woodroffe, G. H.
Wormeley, P. L.
Worth Bros. Co.,
  E. F. Kenney.

Y

York Manufacturing Co.,
  C. H. Ehrenfeld.
Young, C. D.
Young, J. B.
Young, R. B.
Youngstown Sheet and Tube Co.,
  G. A. Reinhardt.

Z

Zeidler, John L.

AMERICAN SOCIETY FOR TESTING MATERIALS.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

PROCEEDINGS.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

OUR SOCIETY.

ANNUAL ADDRESS BY THE PRESIDENT, A. A. STEVENSON.

At this, our twentieth annual meeting, and the end of our fifteenth year as an independent society, it seemed to me that a more appropriate subject could hardly be taken for this address than that of "Our Society." The subject is a broad one and there is a great deal that could be said in detail as to what has been accomplished, the methods of working, and other features. I will, however, confine myself more closely to what may be termed impressions gained from a review of the work that has been done; thoughts of the present; and what seem to me to be some of the general tendencies as to the future, both in the work of the Society and in its relation to sister societies.

Those who were not identified with the early work of the Society may be interested in a brief historical sketch. The American Section of the International Association for Testing Materials was organized in Philadelphia, June 16, 1898, Professor Merriman being the first Chairman. As time went on, those in executive authority felt they should have greater freedom of action than was possible under the statutes of the International Association and desired to form a National Section with power to conduct its own affairs without control of the

Council of the International Association except where such control was obviously called for. This did not meet with the approval of the President and Council of the International Association. It was then decided by the American Section to form an independent association. A charter was applied for in March, 1902, and final action taken at the annual meeting in June of that year. At the time of the organization of the American Society for Testing Materials and until the by-laws were changed in 1905, it was necessary to hold membership in the International Association to be a member of the American Society.

That this action was a wise one does not seem to admit of discussion. As an American Section of the International Association it would have been impossible to accomplish all that has been done during the last fifteen years. Too much credit can hardly be given to the officers and members of the Executive Committee of the American Section and of the Society during the early years of its existence, who, convinced that there was a broad field of usefulness in which a society so constituted as ours could best serve, gave generously of their time and thought and persisted in their efforts until success became assured.

It has been said that "ideas do not take hold in proportion to their goodness; they take hold in proportion to the steam behind them." This may be true; but when the idea is good and there is steam behind it too, the combination is sure to succeed. Has not the success of our Society been due to the goodness of the idea and the steam put behind it?

I will not burden you with statistics. However, I have had some charts prepared giving data concerning a few such items as standards,—their adoption and revision,—finances, publications and membership, which I trust will not prove uninteresting.

Fig. 1 shows the years in which the various standards of Group A, Ferrous Metals, were adopted and the years in which they were revised.

Fig. 2 shows the same information for Group B, Non-Ferrous Metals; Group C, Cement, Lime, Gypsum and Clay Products; and Group D, Miscellaneous Materials.

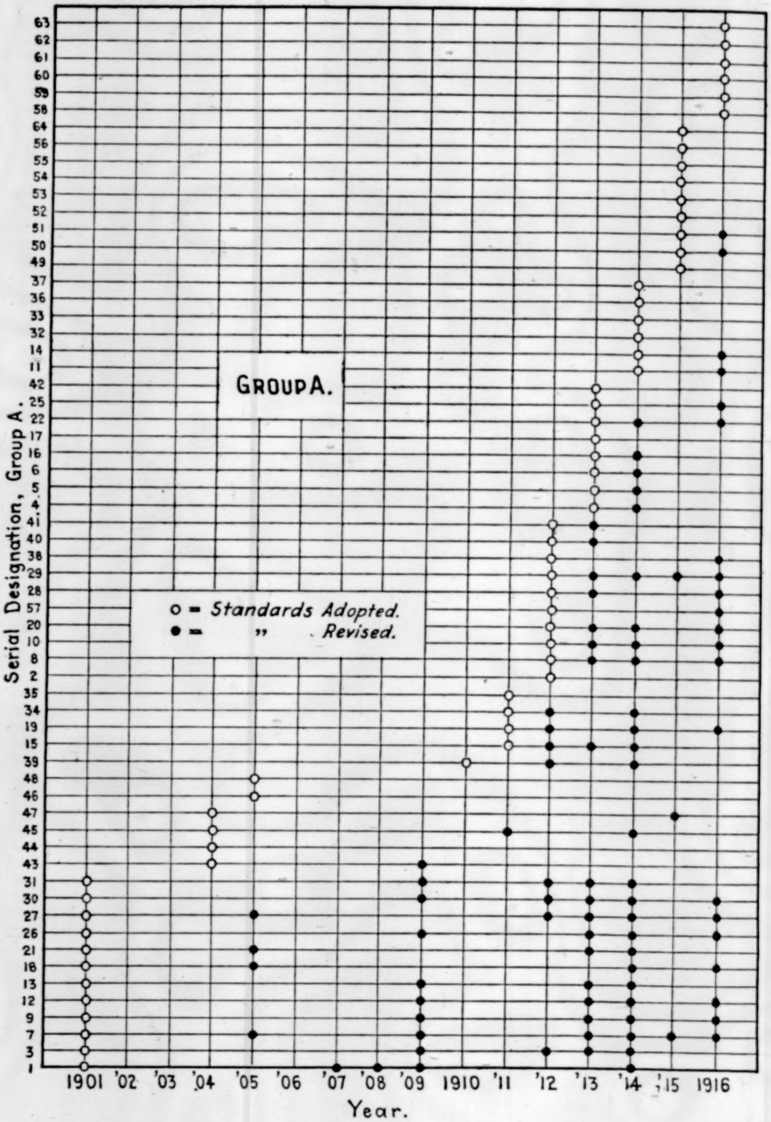


FIG. 1.—Standards of Group A, Ferrous Metals.

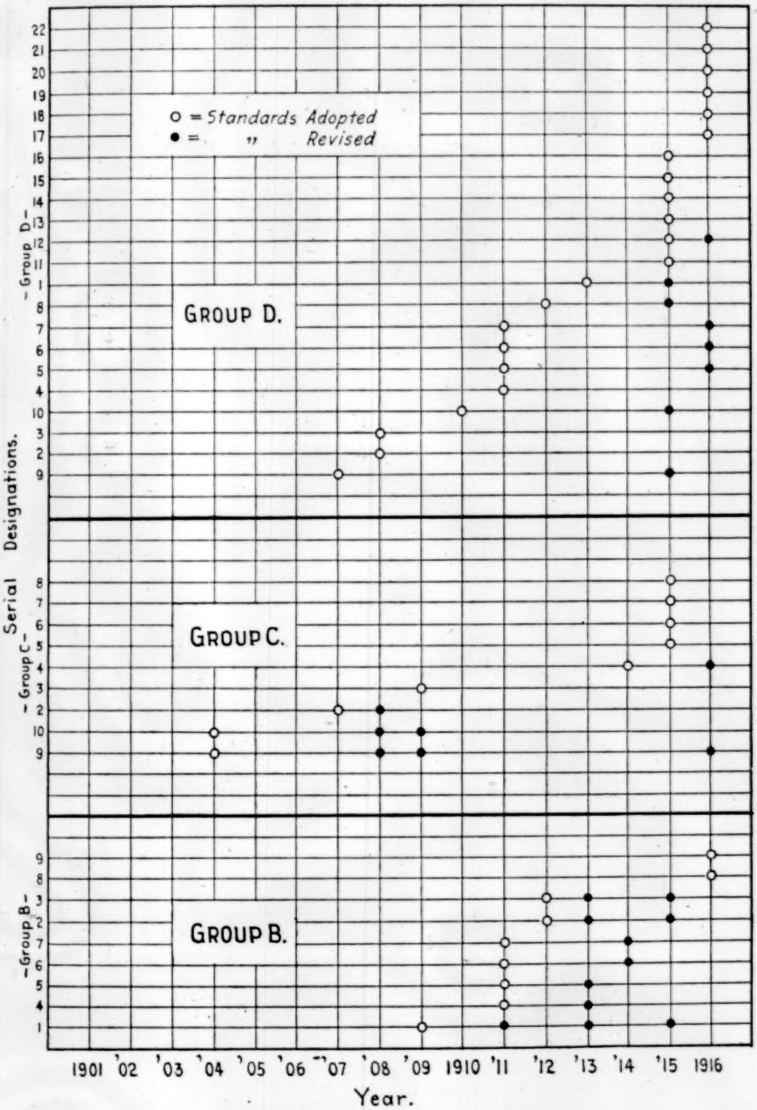


FIG. 2.—Standards of Group B, Non-Ferrous Metals; Group C, Cement, Lime, Gypsum and Clay Products; and Group D, Miscellaneous Materials.

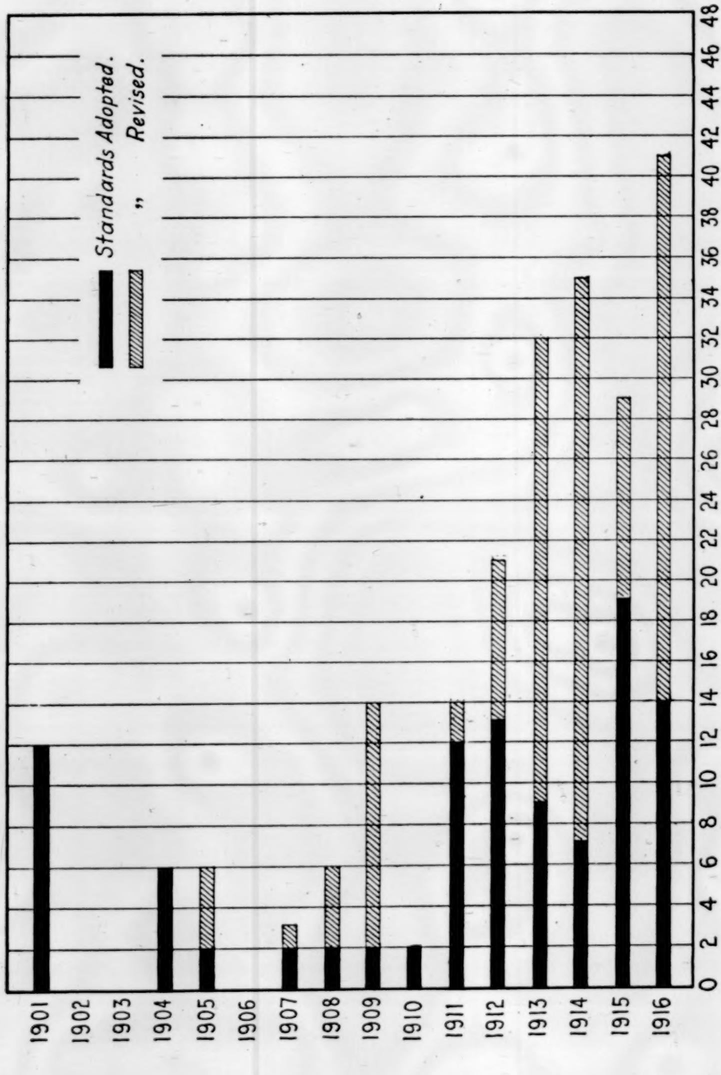


FIG. 3.—Standards of Groups A, B, C and D.

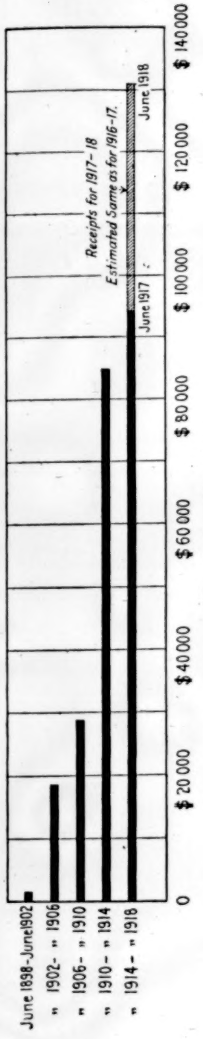


FIG. 4.—Receipts.

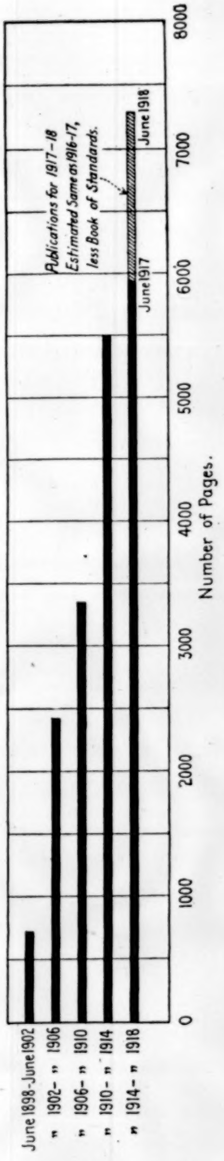


FIG. 5.—Publications.

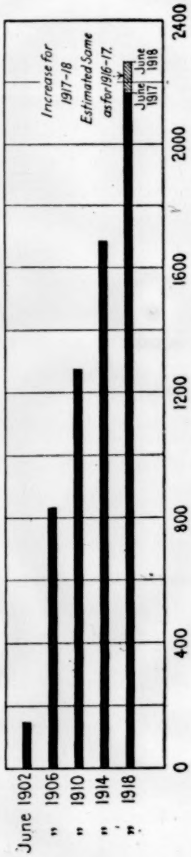


FIG. 6.—Membership.

Fig. 3 shows the total number of standards adopted and revised in the different years.

In Figs. 4, 5 and 6 information is given concerning receipts, publications and membership for four-year periods. This period was adopted so as to have the first line cover the time from the organization of the American Section of the International Association in June, 1898, to the time of the organization of the American Society in June, 1902. While the Proceedings of the annual meeting in 1902 appear in Vol. II as Proceedings of the American Society, the work had previously been done by the American Section. In preparing the charts it seemed to me that the American Section should be given credit for this work. The amounts given in Fig. 4 do not include the Publication and Research Fund reported in 1900, Committee Funds, nor the amount raised by the Society for the Congress of the International Association held in New York in 1912. In Fig. 4 the receipts for 1917–18 have been estimated to be the same as those in 1916–17. In Fig. 5 the publications for 1917–18 have been estimated to be the same as those of 1916–17, less the Book of Standards which will not be issued during the coming year. In Fig. 6 it is estimated that the net increase in membership during the coming year will equal the net increase during the past year. These charts show how regular and consistent the growth of the Society has been.

We speak of tentative specifications as contrasted with standard ones. Figs. 1 and 2 clearly indicate that there are no permanent standards, but that rather they are constantly subject to revision. The Society has been criticised—some of us may think justly so—for being too prone to revise specifications, not allowing existing ones to stand long enough for a thorough trial. The printing of the Book of Standards biennially will have a good effect, as it will give the contained specifications a measure of permanence that will encourage their use. Personally I feel that if the Book of Standards was issued once every three years it would be still better.

That there must be revisions from time to time, all will admit; anything else would imply a lack of progress in the arts and that there were no lessons to be learned from experience. This we know is not the case. Unless we keep in touch with the progress in the arts and profit by the lessons of experience, the usefulness of the Society will soon cease.

In speaking of the past, permit me to draw on my experience in the work of Committee A-1 on Steel, with which I have had the honor to be closely associated. In general it may be said the experience and development of the work of other committees has been along similar lines, so that the example chosen may be regarded as broadly typical.

The development of the committee idea as a means of carrying on such technical work as ours has impressed itself upon me most strongly. The tendency in this direction has been quite marked and the method has proved most efficient. This feature of the work, its growth and development, was most admirably covered in detail by Professor Merriman in his annual address last year, and I have only a few general remarks to offer. As the Society grew in numbers and the field of its work broadened, it would have been impossible for the body as a whole to have given the same time to the detailed discussion of individual specifications as in the early days. That situation was therefore met by throwing more responsibility upon the committees. New rules governing these committees were added from time to time to meet changing conditions and to safeguard the interests of the Society. The natural sequel has been that the Society at large has gradually reached a point where a committee report must establish its right to consideration by the Society through a practically unanimous supporting vote of the committee concerned, the alternative being that the report will be referred back to the committee for further consideration. The knowledge of this fact has reacted on the committees themselves, and has led to more thorough and painstaking work on their part. I have wondered if the fundamental reason committee work has proved so efficient may not be, as expressed by another:

> "We always carry out by committee anything in which any one of us alone would be too reasonable to persist. Alone, after a few trials, one would probably come to his senses, but in a committee we come to one another's senses."

There has been a marked change in the methods of work in committees, and even more perhaps in the spirit in which the work is carried on. In the early years, when a specification was proposed the first step would be to tabulate all the important existing specifications and then to build up from such tabulations. When that stage was reached, the struggle began between the consumers on one side and the producers on the other: the consumers making every effort to get as much as possible; the producers to yield as little as possible. Both parties had certain reasons for their action, the consumers feeling that the producers were unreasonable, the producers feeling that no matter what was conceded some of the consumers would afterwards try to force further concessions in drawing their own specifications. That this feeling of antagonism has largely disappeared should be a source of great encouragement in looking towards the future. Both consumers and producers are realizing more and more that their interests are really mutual and the combined effort now is to endeavor to determine the facts and to use these facts as a basis for their work. We would probably be much astonished did we know the amount of time and money spent on tests and investigations during the last few years.

At the annual meeting in 1902, Doctor Dudley made the following remark:

> "One of the great values of testing is the rejection, and the rigid rejection, of material that does not pass, whether the sample is exactly like the balance of the heat or not. It is the moral effect on the manufacturer of suffering the loss, as we look at it, that is one of the strong elements in the value of testing."

I have wondered if, were the good Doctor here now, he might not look at this phase of the question from a somewhat different point of view, and not emphasize so strongly the penalizing features of a specification. As specifications are based more and more on facts and knowledge rather than on opinion and speculation, the producer and consumer find it less difficult to work together harmoniously. Under ideal specifications—a development which we cannot, of course, hope to reach short of the millenium, but which we may endeavor to approach as nearly as possible—it is conceivable that the producer might regard the rejection of material, not as a penalty, but rather as a protection in keeping from service improper material, failure of which would react on his business and reputation. The ideal specification is one which can be reliably met by a producer who is competent and willing. When a specification is so severe that it condemns much good material, it not only results in economic waste but defeats its own purpose by introducing an element of gambling. Looking back, no doubt we can all recall specifications that operated in a large measure as penalizations and frequently resulted in rejection of fit material. Some of us may feel that even to-day there are instances where this is true.

The Society is greatly indebted to some of the members representing important consuming interests, who took the stand that they were willing to assume an active part in committee work involving much time, provided they could feel assured that the specifications thus finally evolved would be representative of good general practice and fair alike to the consumer and the producer. Apparently in the minds of many of the consumers this point has been reached, for we are safe in saying that, taking the country at large, there are no specifications in such general use as those of the Society, although not infrequently with more or less extensive modifications. Those who are familiar with the field will realize how many specifications have been issued in which the basic requirements were taken from the A.S.T.M. specifications.

While I have dwelt at some length on the development and importance of our committee work, we should bear in mind that the purpose of the Society is two-fold, namely, the promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing. It is fitting, therefore, that mention should here be made of the valuable contributions to the Proceedings of the Society in the form of papers and discussions by many of its members, presenting the results of their investigations in the field which the Society aims to cover. The importance of this phase of our work cannot be emphasized too strongly, not only in its bearing on the "promotion of knowledge of the materials of engineering," but also for its value to our committees engaged in the "standardization of specifications and the methods of testing."

As for the present, the growth in influence and numbers brings in its train added responsibilities and possible dangers. Questions of policy within the Society are such that unless its objects and aims are kept in the minds of the executive officers and the members themselves, decisions are liable to be made that will militate against our future efficiency, impairing the confidence of those outside of the Society, upon whose acceptance of the result of our efforts depend our success and usefulness.

As we become more firmly established in our particular field we should not allow the strength of our position to influence in any way a fair and broad-minded view in our relation to other societies. At many points our activities are closely related with theirs. We should clearly recognize that some questions lie primarily in the field of other societies, and be willing to accept their leadership or work jointly with them. By all means let our effort be to avoid the issuance of different specifications for the same thing. Our aim should be the extension of that cooperation with other societies and Government Bureaus which has been in evidence the past few years.

I think this is an opportune time to call attention to the following remark that appears in the address of Doctor Howe made at the Fourth Annual Meeting in 1901:

> "To our country our work should be of unusual and very direct, special value. We aim to unify the methods of testing materials of construction throughout the world and thereby greatly to facilitate our export trade in those materials and thereby to offset the disadvantages of our relatively isolated geographical position."

Those of us who have kept in touch with the progress, or lack of progress, in so far as international specifications are concerned, have realized how hopeless the task has seemed. The different conditions existing in the several countries and the apparent feeling in some countries that international specifications would militate against their export trade, seem to be the two main difficulties in the way. In fact, universal international specifications would appear to be somewhat of an "iridescent dream," although I feel we should continue our efforts in this direction. At the time Doctor Howe made his address, it was hard to foretell what the developments would be; but is it not true that the work of the Society will nevertheless be of "very direct special value" in facilitating our export trade, evidenced by the fact, with which you are familiar, that many of the A.S.T.M. specifications are being printed in different languages by our National Government for dissemination in foreign countries through U. S. consuls and commercial agents.

I am going to take advantage of the enforced absence of our worthy Secretary-Treasurer to say something to which he would object most strenuously if he were present. In the 1902 Presidential address of Doctor Howe appears the following:

> "In every scientific and technical society there should be at least one permanent officer in order that not only the policy of the society may be continuous, but also that its work may be efficient. Experience shows that this officer should be the Secretary and that he should be the executive officer, who, with the advice of the President and Executive Committee or Council, should not only execute but also shape the policy. . . .
>
> "Your Executive Committee labored for months with this question, and as a result I am confident that in our present Secretary, Edgar Marburg, Esq., Professor of Civil Engineering in the University of Pennsylvania, we have found the man who fulfills all the requirements which I have set forth. For him I predict confidently a successful administration of the affairs of this Society."

That the then Executive Committee chose wisely and well, we all know. The happy selection made at that time must now be a source of great satisfaction to those who made it. I think we all must admit that much of our success has been due to Doctor Marburg's devoted interest in the Society and its work, his untiring energy, his rugged honesty, his fairmindedness, and his jealousy of its good name. Those of us, who by our good fortune as officers and members of the Executive Committee have been closely associated with the Doctor, are in a position to realize more fully than it is possible for others, how many rocks and shoals have been avoided by his keen foresight. We hope that at our next meeting we will see him in his chair.

As to the future, I shall attempt to give only a few of the thoughts that have occurred to me in connection with the development of our work. It seems to me one of the developments of the future will be the increased testing of individual parts; that is to say, so-called "proof testing." As distinguished from the ordinary method of representative testing, it means that individual parts are tested and subsequently used. For example, heat-treated axles and boiler tubes are tested in this way. If called upon to explain the difference between proof testing and representative testing, we might say in the first case the object is to determine what can be used; in the second, what can not be. For some materials it is not easy to see how a method of proof testing can be worked out practically; for others it would appear feasible. If further experience shows the advantage and desirability of this method of testing, we can trust the engineers and the manufacturers to work out a practical solution of the problems involved. As time goes on, may we not also expect developments along this line in magnetic testing that will be of great help and facilitate the inspection of certain materials? It seems to me this field is one of great promise.

As we gain more knowledge of materials and as new methods of testing are developed, there will be less necessity for a number of requirements that are now in our specifications, and as a consequence the specifications will be much shortened, though just as efficient. As better grades of raw material become exhausted, there is no doubt that changes in the requirements as to impurities will have to be given consideration. Personally I feel that time will show that many specifications have requirements covering impurities that are not necessary, and that materials with these requirements raised will be just as reliable as materials furnished under present specifications. Some of the recent literature indicates that the countries now at war, both the Allies and Central Powers, have found that to be true. In discussing the question of copper in steel with a British officer not long ago, I was told that the Germans had presented them with some shells running as high as $1\frac{1}{2}$ per cent in copper.

A tendency that is strongly in evidence to-day is one towards closer cooperation between the various technical societies, just as there is to-day in business a tendency towards cooperation in the broadest and best sense of the word. I do not think Mr. Carnegie realized how well he was building when he made possible the United Engineering Building. Undoubtedly the resulting close relationship of some of our national engineering societies has been a great factor in leading them to closer cooperation. The influence of such cooperation is bound to be felt. Indeed, I look forward to the day when we shall have one general Engineering Society, made up of the various societies as members, their individuality maintained, but the work so correlated as to give greater efficiency and better results.

Our Society is now represented with four national engineering societies, on a committee which is trying to evolve some plan of closer cooperation whereby standards may be made national. The problem is a difficult one and it is impossible at the present time to tell just what the outcome of the efforts of this committee will be. The committee has made a report to the governing boards of the five societies suggesting the formation by the societies of an American Engineering Standards Committee. The object of this committee would be to unify and simplify the methods of arriving at engineering standards, to insure cooperation between the different societies, and to prevent duplication of work. There has been insufficient time for the consideration of this report by the governing bodies of these societies. Undoubtedly the scheme will undergo modifications and obstacles may arise that have not been considered. I hope the general scheme will have a favorable reception. If it does, the result will be far-reaching and the ultimate effect will be not only to strengthen the individual societies but also through the coordination thus effected to give to the adopted standards and specifications a standing that they could otherwise not attain.

I cannot close without referring to that which is uppermost in the minds of all at the present time. We are in the midst of the greatest war the world has ever known. There seems to be no doubt that the final outcome is going to result in changes in the life of nations—political, social and economical—beyond anything thought of or imagined a few years ago. The present war is not only one of men, but of science and engineering. We are all familiar with what science and engineering have done for the advancement of civilization in times of peace. Little could we dream of what the same science and engineering have done when degraded to the work of destruction.

You have been informed as to the action taken by your Executive Committee in offering the services of our organization to the Government to be used in such a way as may be deemed best for the good of the cause. What the result of this offer will be, we cannot say at present, but the members of the Society will be kept informed of any developments. That the Society as a whole stands ready in the present crisis, we cannot doubt. There is something for everyone to do. If we cannot fight, we can give of our energy, our time and our means; we can stimulate and encourage those at the front by the knowledge that they have behind them a united people that stand as one to do their part to bring the war to a speedy and successful conclusion.

With character as with materials, there are elements to be avoided, as well as those that are necessary to best fit us for the service demanded. Much is demanded from the nation and the individual in the present crisis. As a nation and as individuals, should we not make every endeavor to keep down the phosphorus of selfishness and the sulphur of hate? Then, tempered by the carbon of charity, solidified by the silicon of hope, purified by the manganese of faith, strengthened by the alloy of patriotism, let us go forward! We know not what the future may have in store; let us be prepared to give of self and service and to make any sacrifice that may be necessary; confident that "right, not might" will prevail; confident of victory —not a victory of conquest and aggression, but a victory for democracy and civilization; confident that our nation will meet the calls made upon it and come through the ordeal sobered and chastened, with higher ideals, both national and individual. Lloyd George once said that it is not what a nation gains that makes it great, but what it gives. A full realization of this thought by the nation and the individual will do more than any other one thing to inspire them to give such aid to those nations with whom we are allied in this war as will make ultimate success a certainty.

Why the world should pass through such a fire, and why it should be called upon to make such a sacrifice, we in our day and generation may never know. We must believe that those who come after us will know. We must believe that as the future generations look back, they will understand that great as was the sacrifice, stupendous as was the price, the sacrifice was not made nor the price paid in vain. We must believe that terrible as is the catastrophe, through it all unseen by us the hand of Providence is working. Without such a belief, how dark would seem the future and how useless the sacrifice. With this belief in our hearts as we enter upon the task before us,

"May we have faith to look with fearless eyes,
Upon the tragedy of a world at strife,
And know that out of death and night
Shall rise the dawn of ampler life."

ADDRESSES BY PAST PRESIDENTS.

Mr. A. W. Gibbs: President, 1914–1915.

Gentlemen, I came down here in a very light hearted manner, having been assured by the President that I would not have to speak this evening, and that he was going to so advise the Chairman. Certainly the Chairman was not advised or did not act on the advice, and between these two, who have been my friends in the past, I find myself treated in this treacherous way.

While Mr. Stevenson has been talking, I have been wondering what is going to be the future of this Society in its organization. We are in a rather curious position at present. We have in Philadelphia no executives except past and outgoing presidents. When we have important meetings, we frequently go to the United Engineering Building in New York City. Now I have been in a position to watch this Society from a very early date, having been closely associated with Doctor Dudley, and I know the worries about its future, largely because of hampering means; and really in the early days of the Society, you might say that we "sponged" on the University. Then we had a Secretary who could give a little of his time; but as the Society strengthened, the Secretary has been able to give more of his time, and I have been wondering whether, in the long run, our Society will not be in the same place, maybe in the same building, with the other big engineering societies, for the reason that people can do a great deal more by direct conference than by correspondence. That may be somewhere in the future, but I feel very certain it is going to be the outcome, that the headquarters will be there and our general meetings will be held there as well as the committee meetings which now are held there.

In the other societies we can see very distinct signs that our specifications are being adopted, either in whole or in part; in the mechanical railroad associations, a number of our specifications, almost word for word, are being adopted. We believe that more will come. Yesterday I was taking part in the meeting of the American Railway Engineering Association Committee on Rail. That committee came down here to meet because our Society was meeting here, and everywhere that I go I see and hear less of the old suspicion that this Society was being run by certain interests, and more recognition of the fact that it is a broad engineering society, and this is the most hopeful sign that we could have.

MR. ARTHUR N. TALBOT: PRESIDENT, 1913–1914.

Mr. Chairman, the President's address this evening has brought to my mind a number of matters in the development of the Society about which I had not thought for some time. I was in attendance, I believe, at the second meeting of the Society, and it has been my good fortune to attend most of the meetings since that time. The change of organization from the American Section of The International Association for Testing Materials to an independent body with only indirect connection with the International Association was one of the great advances which the Society made, getting away from the methods of government and away from some of the ideals of the parent society. It is rather strange, I think, that in this country a special society of this kind should have grown up as it did, taking away from the older national societies and the scientific societies the prerogatives, the opportunities, which would be thought to belong to them or which they thought belonged to them.

Through these years a great work has been done by the American Society for Testing Materials. This has been accomplished largely through work done by the membership. This work has been done in two ways: first, in the reporting of scientific work, scientific and technical data and results, direct to the Society and to the committees in a way which is not done to any such extent, I believe, by another society; and second, in the great work done by the committees themselves, for the committee work of the Society has constituted its especial strength. One other society in this country with whose work I am familiar, does its work in much the same way through the operation of committees,—the American Railway Engineering Association, another great, active, vigorous, virile, progressive, successful society.

Twenty years have seen a great change, a great development in materials and processes and manufacture and uses, and one would almost think, after looking over the modifications which have been made and after considering the progress of these years, that we must soon show less striking progress—that we must expect to approach the asymptote of perfection only gradually. But after all, when we consider the events of the last two or three years, we must conclude that other kinds of activity are coming, that there are new fields and new activities, and that the future will be just as fruitful of accomplishments as the past. With the present situation in view, who will say that the American Society for Testing Materials will not play a very important part in the wonderful developments which will come in the next twenty years just as surely as they have come in the past twenty?

CAPT. ROBERT W. HUNT: PRESIDENT, 1912–1913.

Mr. Chairman, Ladies and Gentlemen: It gives me great pleasure to participate in this Society's twentieth celebration, and I think you will agree with me as to how remarkable it is that all of the presidents of the Society, with the exception of one, are privileged to be with us to-night, and happily our first president can preside at this meeting. I know you will join with me in wishing to Professor Merriman many years of continued health and happiness. But we miss one, and that one, whose taking away from us caused us all such sorrow, had during his life patriotically and with prescience, which is now manifest, assisted to prepare for meeting the existing conditions of our country. You may remember the active part that Doctor Dudley played in the development of the safe transportation of explosives, which, at the time of his work, was practically entirely related to the arts of peace; but the results obtained must now play an important part in this great struggle in which we are engaged, and this Society, which Doctor Dudley did so much to build up, has also played a large part during its years of existence in helping to prepare our nation for its present struggle. Its work has done much to bring together the manufacturer and the specialist; it has brought about conditions of advancement in the manufacture of materials which are now so important in the prosecution of this war, and which twenty years ago would have been impossible.

Speaking as a manufacturer of the past, and also as one who has helped to have the progressive specifications which have been developed during these later years, successfully, and therefore practically, applied, I think it is my privilege to-night to speak as one knowing: and with that knowledge, it troubles me that some of our authorities at Washington do not seem willing to trust the American people, not seeming to realize that the greater the interests, I mean the material interests, of this country, the greater the part those interests must play in whatever this country does, and it must rely upon those administering the affairs of those interests for the development and the exercise of the highest patriotism. The men who have built up these great organizations are Americans, and they must fully realize, if only from selfish motives, that the success of our country is vital to the success of their own industries; and therefore I believe they can be trusted; and I know that they can administer the organization with which they are so familiar, the machinery which they have built, better than any "'prentice hand" which can be put upon it, and God forbid that such placing shall happen.

It has been my fortune to live to see our country engaged in four wars, and thus naturally during our present troubles I recall many things of the past ones. I remember the pride which, as a boy, I felt when in 1848 I was taken by my father to a Fourth of July celebration in Trenton, New Jersey. The honored guest of the day was Commander Hunter of the Navy, or, as he was familiarly called, Charlie Hunter. He had been sent back from Mexico under reprimand because there, where he commanded a ship, he was ordered to make a reconnaissance upon a fortified Mexican town, and when executing the order he found such conditions existing that he quietly sent his marines ashore, took possession, and raised the American flag over the fortifications. We held the fortifications, but Charlie Hunter was sent back as stated, under a reprimand, to become, as you can easily imagine, the idol of the hour of the American people. I think that we have upon two or three other occasions had examples of where the American navy have seen patriotic opportunity and successfully acted upon it, and thank God to-day the American navy is the one feature of our armed organization which is nearest to being in condition to take care of itself and take care of us, and we can always trust it.

Now this unholy war is so unholy that the language to describe it is unfit for utterance in a mixed assembly like this. "Vengeance is mine, saith the Lord." The Kaiser calls upon God, but if the divine word can be read aright, the Lord's vengeance is awaiting the violators of—oh, what can I say? How speak of the prostitution of science; the forgetfulness of all attributes of humanity of which that German—I won't say nation—that German army has been guilty; and there can be but one answer; there can be but one result, if there is a just God, and there surely is one, and that will be the overthrowing and overwhelming of that German power.

I do not want to see this war ended until the American flag has been planted before the enemy. I do not wish to see a drop of American blood spilled, and I certainly hope that pain and suffering may be spared our armed representatives; but nevertheless, let that come as it may, it will be a sacrifice well given if we prove to the world and ourselves that our flag represents what it has always professed to represent, and that American manhood stands ready to die under it, in defense of the principles of which it is typical.

MR. HENRY M. HOWE: PRESIDENT, 1900–1902; 1910–1912.

Twenty years old! We are twenty, with the vigor and hopefulness of twenty, at the crest of adolescence, looking forward eagerly to our next birthday when we shall really be of age.

At this as at every birthday it is well to bring up freshly before us our great underlying purpose, service, the service of our fellows, first by teaching them and each other how we may best determine the fitness of the materials of construction, second by setting up just and reasonable specifications, which shall safeguard the interests, indeed often the lives, of our great client, mankind. We gather here that we may improve this service, by consultation and discussion, giving freely of our very selves, of our time, and of our best thought.

This year our efforts are stimulated by the thought that our planning, our care, and our work are part of our bit, are part of our contribution towards sustaining our brothers and our sons in the trenches, and towards delivering the world from its fearful peril of falling under the heel of scientific barbarism. Which of us would care to live if life meant subjection to Prussian brutality? Every man here now understands fully for the first time the true meaning of the words we used to declaim, "Give me liberty or give me death."

MR. MANSFIELD MERRIMAN: PRESIDENT, 1898–1900; 1915–1916.

Ladies and gentlemen, it is nineteen years ago this month that the first meeting of the American Section of the International Association for Testing Materials was held. This is the twentieth annual meeting. Much has been accomplished in that time. When we began we had little or no idea as to what would happen. On the morning after that meeting was held in Philadelphia, a brief notice appeared in a newspaper, stating that I had served as chairman. A day or two later there came to Lehigh University, where I was then stationed, a package addressed to me, weighing about a pound and a half, accompanied by a letter saying "I send you this lot of ore or rock; kindly test it and tell me how much it is worth." Such was the idea of the function of a society for testing materials held by some people at that time. We have gone on and accomplished things of which we then never dreamed. There have been seasons of depression, especially in the earlier years, but there were, in those days, a few good workers. The seeds were planted; the foundation was laid. When the eleven specifications and the tabular sheets were issued in 1899, I saw there what, at that time, we did not dream would be so fruitful. It reminds me now of the saying about the location of a railroad: "Locating a railroad is giving it its constitution; it may be sick even unto death, but if it has a good constitution, it will ultimately recover." And so, in the first few years, we planted good seed. There came times of depression, of anxiety, but somehow or other we survived and a policy was inaugurated in 1902 which has proved successful. Long may it continue!

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE.

Publications.—The regular publications issued during the past year again exceed in volume those of any earlier year, the comparison for the past three years being as follows:

	1914–15. Pages	1915–16. Pages.	1916–17. Pages.
Proceedings	1162	962	1114
Book of A.S.T.M. Standards	500	757	752
Membership Pamphlet	219	247	229
Total	1881	1966	2095

Ten circulars to members aggregating 48 pages have also been issued during the past year. In pursuance of the new policy governing publications, which became effective upon affirmative action by letter ballot of the Society on September 1, 1916, the book of A.S.T.M. Standards theretofore published annually as a "Year-Book" will hereafter appear biennially, the first volume under that change having been published last year. This latest book of A.S.T.M. Standards (1916) contains 103 standards, of which 16 are new and 28 revised. Under the new procedure the 30 Tentative Standards and 4 Tentative Revisions of Standards were published last year only in the Proceedings (Vol. XVI, Part I, pp. 410–595), under a section designated "Tentative Standards," as prescribed by the by-laws.

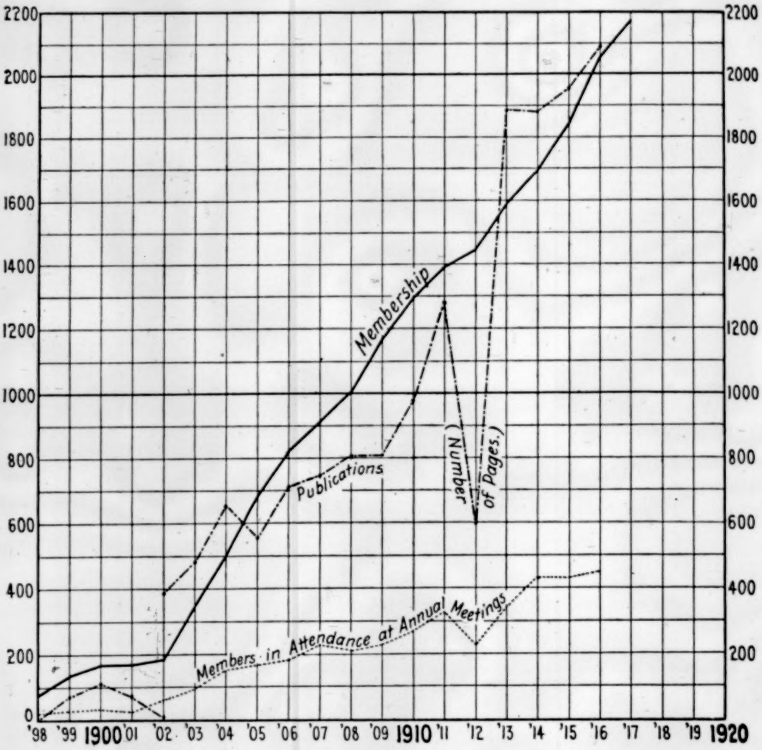
It has been suggested that Tentative Standards shall, in the future, be published in the form of a separate pamphlet and not in the Proceedings. Since the omission of the Tentative Standards from the Proceedings would be contrary to the by-laws, the Executive Committee wishes to submit to the Society at this meeting, for such action as may be taken pending the appropriate amendment of the by-laws, the question of the publication of the Tentative Standards only in the Proceedings or as a separate publication.

Membership.—The membership at the last annual meeting was 2071. Since then 265 applications for membership have been approved as compared with 413 during the previous year. The losses by death number 10, namely:

L. H. Bowman	June 27, 1916
C. H. Cartlidge	June 14, 1916
W. C. Cuntz	November 2, 1916
Theo. N. Ely	October 29, 1916
C. J. Gadd	January 2, 1917
R. B. Kendig	May 10, 1917
C. Kirchhoff	June 23, 1916
F. J. Machalske	January 6, 1916
C. T. Wetherill	January 17, 1917
Otto C. Wolf	December 19, 1916

The number of resignations is 90 and 69 members have been dropped for non-payment of dues, the former number being 12 less than and the latter 3 in excess of the corresponding number for the previous year. The total losses for the year from all causes number 169, and the net increase in membership for the year is 96, as compared with 229 for the previous year, and with an average net annual increase of 142 for the preceding five years. The drop in the net increase in membership for the year as compared with the previous year is due to the fact that fewer applications for membership have been received during the past year, the loss by resignations and for non-payment of dues having been 9 less than last year. The great excess of new applications for the previous year as compared with last year may be attributed to a movement inaugurated late in 1915 towards increasing the membership of the Society, especially through the participation of the standing committees through sub-committees appointed for that purpose. It is apparent, therefore, that the efforts of these sub-committees might well be renewed with distinct advantage to the Society. The total membership of the Society is now 2167, of whom 207 are Junior Members.

Standing Committees.—The activities of the standing committees, which have always been such a notable factor in the achievements of the Society, have shown no abatement during the last year. In addition to the results which will be reported by committees at this annual meeting, much work has been done by other committees who are not yet prepared to report definite conclusions.



NOTE.—The initial curve for publications (1898–1902) refers to the publications of the American Section of the International Association for Testing Materials. The marked drop for 1912 in the "publications" and "members in attendance at annual meetings" curves is due to the fact that the Sixth Congress of the International Association was held in New York in September, 1912, and that the activities of the American Society for that year were accordingly restricted to committee reports and administrative business.

The list of Standing Committees has been increased during the year by the creation of two new committees, namely:

Committee E-4 on Magnification Scales for Micrographs;
Committee E-7 on Classification of Technical Literature Concerning Materials.

Committee A-8 on Cold-Drawn Steel has been discontinued as an independent committee with its consent, and is now merged with Committee A-1 on Steel, of which it is a subcommittee.

At the suggestion of Committee E-5 on Standing Committees, and with the approval of Committee A-3, the designation of the latter committee has been changed from that "On Cast Iron and Finished Castings" to that "On Cast Iron."

Otherwise the list of Standing Committees has undergone no changes during the past year.

Since the last annual meeting the following subscriptions towards the conduct of research work by various standing committees have been contributed to the treasury of the Society:

Committee A-5 on Corrosion of Iron and Steel	$1489.96
Committee C-1 on Cement	4700.00
Committee C-9 on Concrete and Concrete Aggregates	2000.00
Total	$8189.96

The Regulations Governing Standing Committees provide that any recommendations affecting standards must be sent in printed form to every member of the Society not less than four weeks before the annual meeting at which these recommendations are to be presented. This regulation has been observed in connection with the matter listed below, with the exception of the items distinguished by an (*), concerning which the reports were not received in time to make this feasible.

I. PROPOSED NEW STANDARDS.

NOTE.—The following proposed Standards have been published for two years as tentative with the exception of certain parts of the Methods for Sampling and Analysis of Creosote Oil.

Recommended by Committee D-1 on Preservative Coatings:

Tests for Paint Thinners Other than Turpentine.
Tests for Shellac.
Methods for Routine Analysis of White Pigments.

Recommended by Committee D-7 on Timber.

Methods for Sampling and Analysis of Creosote Oil.

II. PROPOSED NEW TENTATIVE STANDARDS.

Recommended by Committee A-1 on Steel:

For Carbon Tool Steel.

Recommended by Committee A-2 on Wrought Iron:

*For Wrought-Iron Pipe.
*For Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars.

Recommended by Committee A-3 on Cast Iron:

*For Cast-Iron Soil Pipe and Fittings.
*For Railroad Malleable-Iron Castings.

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

For Brass Forging Rod.
For Free-Cutting Brass Rod for Use in Screw Machines.
For Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings.

Recommended by Committee C-4 on Clay and Cement Sewer Pipe:

For Clay Sewer Pipe.
For Cement-Concrete Sewer Pipe.
For Trench Pressures upon Sewer Pipe.

Recommended by Committee C-5 on Fireproofing:

Time-Temperature Curve for Fire Tests of Building Construction.

Recommended by Committee C-7 on Lime:

*For Masons' Hydrated Lime.[1]

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* It was not feasible to distribute these proposed tentative standards four weeks in advance of the annual meeting.

[1] Designed to replace, when adopted, the present Standard Specifications for Hydrated Lime (C 6–15).

Recommended by Committee C-8 on Refractories:

Test for Refractory Materials under Load at High Temperatures.

Test for Slagging Action of Refractory Materials.

Methods for Ultimate Chemical Analysis of Refractory Materials.

Recommended by Committee D-1 on Preservative Coatings:

Methods for Routine Analysis of Dry Red Lead.

Methods for Routine Analysis of Yellow, Orange, Red and Brown Pigments containing Iron and Manganese.

Recommended by Committee D-2 on Lubricants:

Tests for Lubricants.

Recommended by Committee D-4 on Road Materials:

Definitions of Terms Applicable to Materials Relating to Roads and Pavements.[1]

Recommended by Committee D-7 on Timber:

For Wooden Paving Blocks.

Methods for Analysis of Creosote Oil.[2]

Recommended by Committee D-8 on Waterproofing:

*For Asphalt for Waterproofing.

*For Primer for Use with Asphalt for Waterproofing.

*For Coal-Tar Pitch for Waterproofing.

*For Creosote Oil for Priming Coat with Coal-Tar Pitch for Waterproofing.

Recommended by Committee D-9 on Electrical Insulation:

Tests for Molded Insulating Materials.

Recommended by Committee D-10 on Shipping Containers:

For Canned Foods Boxes, Nailed and Lock-Corner Construction.

For Canned Foods Boxes, Wirebound Construction.

Recommended by Committee D-11 on Rubber Products:

For Air-Line Hose for Pneumatic Tools.

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* It was not feasible to distribute these proposed tentative standards four weeks in advance of the annual meeting.

[1] To be included, when adopted, in the Standard Definitions of Terms Applicable to Materials Relating to Roads and Pavements (D 8–15).

[2] To be included, when adopted, in the Proposed Standard Methods for Sampling and Analysis of Creosote Oil.

Recommended by Committee E-4 on Magnification Scales for Micrographs:

Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys.

III. PROPOSED REVISIONS OF STANDARDS TO BE PUBLISHED AS TENTATIVE.

Recommended by Committee A-1 on Steel:

For Blooms, Billets and Slabs for Carbon-Steel Forgings (A 17–13).
For Carbon-Steel and Alloy-Steel Forgings (A 18–16).
For Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19–16).
For Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 63–16).
For Lap-Welded and Seamless Steel Boiler Tubes, etc., for Locomotives (A 28–16).
For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52–15).
For Welded Steel and Wrought-Iron Pipe (A 53–15).
For Automobile Carbon and Alloy Steels (A 29–16).
For Boiler and Firebox Steel for Locomotives (A 30–16).

Recommended by Committee A-2 on Wrought Iron:

*For Staybolt Iron (A 39–14).
*For Refined Wrought-Iron Bars (A 41–13).

Recommended by Committee A-3 on Cast Iron:

*For Gray-Iron Castings (A 48–05).

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

For Spelter (B 6–14).

Recommended by Committee C-5 on Fireproofing:

For Fireproof Floor Construction (C 2–08).
For Fireproof Partition Construction (C 3–09).

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* It was not feasible to distribute these proposed tentative standards four weeks in advance of the annual meeting.

Recommended by Committee D-4 on Road Materials:

Test for Toughness of Macadam Rock (D 3–08).

Method for Distillation of Bituminous Materials Suitable for Road Treatment (D 20–16).

Recommended by Committee E-1 on Methods of Testing:

Methods for Testing (E 1–16).

IV. PROPOSED REVISIONS OF TENTATIVE STANDARDS.

Recommended by Committee A-1 on Steel:

For Steel Tie Plates (A 67–16 T).

For Boiler and Firebox Steel for Stationary Service (A 70–16 T).

Recommended by Committee C-4 on Clay and Cement Sewer Pipe:

Recommended Practice for Laying of Sewer Pipe (C 12–16 T).

Recommended by Committee D-4 on Road Materials:

Test for Determination of Apparent Specific Gravity of Coarse Aggregates (D 30–16 T).

During the year a number of changes have been made in the Regulations Governing Standing Committees by joint action of Committee E-5 and the Executive Committee. These changes appear in detail in the report of Committee E-5 and are therefore not repeated here.

Finances.—The annual report of the Executive Committee last year contained the following comment on the anticipated result of the increase of dues which went into effect on January 1, 1916:

> "From present indications it is to be anticipated that, barring expenditures in unexpected directions, the deficit of $6407.03 at the beginning of the fiscal year will not only be extinguished, but that it will be converted into a moderate surplus by the end of the year, and that the financial affairs of the Society will thereafter be on a thoroughly sound business basis for the first time in the history of the organization."

It will be noted with satisfaction, from the report of the auditors for the fiscal year ended December 30, 1916, that the above deficit has been converted into a surplus of $3140.09, thus placing the Society in the strongest financial condition it has experienced in its history. After making allowance for a natural increase in expenses due to the normal growth of the Society, and in the cost of publications owing to the advancing prices of materials, especially paper, it is to be confidently expected that a comfortable surplus will have accumulated by the end of the current fiscal year.

The Executive Committee desires to take this opportunity to express its appreciation to the members of the Society for their loyal support in its recommendation of increased dues as a measure of imperative necessity. The members of the Society can well realize the advantage of this action in that it has enabled the Executive Committee not only to cancel the deficit, but also to take care of the increased cost of publications due to the present abnormal conditions.

During the past year the Executive Committee has given careful and thorough consideration to the permanent form in which the annual financial statements, reported to the Society in the annual report of the Executive Committee, should be published. The form of the following financial statements, which will be adhered to in future years, was approved by two firms of certified public accountants before its final adoption by the Executive Committee.

REPORT OF AUDITORS FOR THE FISCAL YEAR JANUARY 1, 1916, TO DECEMBER 30, 1916.

JOHN HEINS & CO.
PUBLIC ACCOUNTANTS AND AUDITORS.

PHILADELPHIA, January 4, 1917.

Mr. Edgar Marburg, *Secretary-Treasurer*,
American Society for Testing Materials,
Philadelphia, Pa.

Dear Sir:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 30, 1916; having previously made a similar audit and report for the preceding six months ended June 30, 1916, and at both audits found the accounts to be correct; and to be in their usual excellent condition.

We submit balance sheet as of December 30, 1916, as also a statement of operations for the twelve months then ended, schedules of accounts receivable, etc.

Respectfully submitted,
(Signed) JOHN HEINS & CO.

BALANCE SHEET DECEMBER 30, 1916.

ASSETS.

Cash		$845.78	
Accounts Receivable:			
Other than Members	$1,065.24		
Members for Publications	174.45		
Members for 1916 Dues	1,355.55		
		2,595.24	
			$3,441.02

LIABILITIES.

Accounts Payable		none	
Members dues paid in advance		$300.93	
Life Membership	$1,300.00		
Surplus	1,840.09		
		3,140.09	
			$3,441.02

NOTE.—The stock of back publications and the office furniture are not appraised or included in this statement.

MISCELLANEOUS FUNDS.

In addition to the above cash the Secretary-Treasurer has on hand the following Funds:

International Association for Testing Materials, Trust Fund		$1,766.50
Committee A-5 on Corrosion of Iron and Steel	$359.84	
Committee C-1 on Cement	6,021.84	
Committee C-9 on Concrete and Concrete Aggregates	804.62	
Committee C-10 on Hollow Building Tile	90.85	
		7,277.15
Total		$9,043.65

RECEIPTS AND DISBURSEMENTS.

JANUARY 1 TO DECEMBER 30, 1916.

Cash on hand January 1, 1916			$103.54
RECEIPTS.			
Current dues	$28,796.70		
Past dues	330.50		
Advance dues	300.93		
		$29,428.13	
Binding (Members)		279.00	
Sale of Publications:			
Separate standards	$481.26		
Book of Standards, Proceedings, etc.	3,984.90		
		4,466.16	
Sale of right to reprint standards		1,450.00	
Authors' reprints		272.52	
Sale of Certificates of Membership		32.50	
Interest on deposits		141.86	
Sale of metal (Electros, Vols. VI–XV)		321.65	
Miscellaneous		19.25	
Total receipts			36,411.07
			$36,514.61
DISBURSEMENTS.			
Publications		$23,719.35	
Salaries: Secretary-Treasurer	$3,600.00		
Assistant to the Secretary	1,200.00		
Regular clerical	2,480.00		
Extra clerical	841.19		
		8,121.19	
Expenses, Standing Committees		1,481.01	
Expenses, Nominating Committee		53.30	
Expenses, Secretary-Treasurer's office		696.00	
Postage and expressage, Secretary-Treasurer's office		574.31	
Filing cabinet		50.00	
Rent and Insurance, Storage room		201.60	
Auditing accounts		95.00	
Engrossing eertificates of membership		14.55	
Stenographer, annual meeting		200.00	
Net expenses, annual meeting		247.57	
Appropriation to Joint Committee on Concrete and Reinforced Concrete		175.00	
Refund of excess remittances		39.95	
Total disbursements			$35,668.83
Cash on hand, December 30, 1916			$845.78

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1912–1916 INCLUSIVE.

Fiscal Year.	Assets.			Liabilities.	Deficit or Surplus.	
	Cash Balance.	Accounts Receivable.	Total.	Accounts Payable.	Deficit.[a]	Surplus.
1912	$1 216.47	$385.79	$1 602.26	$2 500.00	$897.74	......
1913	1 139.87	662.19	1 802.06	5 393.01	3 590.95	......
1914	43.57	1 044.74	1 088.31	6 421.27	5 332.96	......
1915	103.54	1 481.80	1 585.34	7 992.37	6 407.03	......
1916	845.78	2 595.24	3 441.02	300.93[b]	....	$3 140.09[c]

[a] This deficit includes a reserve for uncollected membership dues for the respective years as follows: $705; $874.50; $765; $813.

[b] This sum represents 1917 dues paid in advance and it includes no unpaid bills.

[c] Of this surplus of $3,140.09, $1,300.00 is on account of Life Membership.

It will be observed that the assets do not include an appraised value of office furniture and fixtures, and of the large stock of back publications whose inventory appears elsewhere in this report.

The receipts in 1916 from the sales of publications amounted to $4466.16 and the receipts from the sale of rights for one year to reprint certain Standards of the Society were as follows:

Carnegie Steel Company	$250.00
Illinois Steel Company	100.00
Jones & Laughlin Steel Company	250.00
National Tube Company	100.00
Portland Cement Association (1915)	250.00
Portland Cement Association (1916)	250.00
Southern Pine Association	250.00
Total	$1450.00

Inventory and Cost of Publications in Stock.—In the foregoing financial analysis no account has been taken of the assets of the Society in the form of publications in stock. The inventory of the Proceedings on May 1, 1917, is as follows:

VOLUME.	COPIES.	VOLUME.	COPIES.	VOLUME.	COPIES.
I	22	VII	393	XIII	478
II	131	VIII	408	XIV, Part I	585
III	27	IX	532	XIV, Part II	579
IV	153	X	451	XV, Part I	417
V	325	XI	410	XV, Part II	389
VI	657	XII	153	XVI, Part I	425
				XVI, Part II	427

Total stock of Proceedings, 6962 volumes.

The stock of publications in general may be summarized as follows, the prices approximating original manufacturing cost:

Proceedings	6962 copies at $1.50	$10 443.00
Index (Vols. I–XII incl.)	753 copies at 0.50	376.50
Reports of Committee D-1 (1903–1914 incl.)	378 copies at 1.75	661.50
Total cost of publications in stock		$11 481.00

Proposed Amendment of the By-Laws.—The Executive Committee recommends the following changes in the by-laws:

ARTICLE II. OFFICERS AND THEIR ELECTION.

Sec. 3. Strike out:

> "The terms of office shall begin at the time of this announcement, except that the retiring President shall continue as presiding officer of the sessions of the Society throughout the Annual Meeting. The President-elect shall be the presiding officer at any session of the Executive Committee that may be held after the announcement of his election.",

and substitute:

> "The terms of office shall begin at the close of the Annual Meeting."

ARTICLE III. NOMINATION OF OFFICERS.

Sec. 2. After the fourth sentence, closing with the words "and one alternate for each of these members," add the following:

> "Members of the Executive Committee shall be ineligible for appointment on the nominating committee. The members of the nominating committee for the previous year shall not be eligible for appointment on this committee for the immediately succeeding year."

In connection with the proposed amendment of Article III it should be stated that the appointments on the nominating committee for this year were made in conformity with the above proposed provisions, in accordance with the action taken at the last annual meeting when it was decided to offer these amendments this year.

Note to the Title of the Standard Specifications and Tests for Portland Cement.—At the sixth session of the last annual meeting considerable discussion developed in connection with the title and a proposed explanatory note to the title of the revised standard specifications and tests for Portland Cement. By action at that meeting "the entire matter, as well as any future questions affecting titles of standards" was left with power to the Executive Committee.

At a special meeting, held on August 7, 1916, at which Committee C-1 was represented by special invitation, the Executive Committee decided that the established practice of the Society should be followed in the title to these specifications, and the following title was accordingly adopted: "Standard Specifications and Tests for Portland Cement." At this meeting the form of the note to follow the title was discussed and at the regular meeting in October the following note was adopted and subsequently published in the book of A.S.T.M. Standards:

> "These specifications are the result of several years' work of a special committee representing a United States Government Departmental Committee, the Board of Direction of the American Society of Civil Engineers, and Committee C-1 on Cement of the American Society for Testing Materials.

Afterwards the phrase "in cooperation with Committee C-1" was added with the approval of the Executive Committee.

Certain objections having been made by Committee C-1 to the publication of the note in the above form, the subject was carefully reviewed by the Executive Committee at its meetings in January and April, at both of which Committee C-1 was represented. At the April meeting it was decided that the interests of the Society would best be served by omitting the note entirely. This will accordingly be done in connection with future issues of the Specifications.

Translation of Certain Standards into Foreign Languages by the U. S. Department of Commerce.—As announced in the last annual report of the Executive Committee arrangements have been made with the U. S. Department of Commerce by which such of the standards of the Society as have an important bearing on the requirements of export trade will be translated into foreign languages by the Department of Commerce without expense to the Society, with a view of distributing these standards among the U. S. Consular offices and making them available at moderate prices to American manufacturers and others interested in foreign trade. The details of this agreement were published in the report of the Executive Committee last year.

The progress in this matter has been somewhat disappointing. The work of the translation has been delayed by a combination of circumstances beyond the control of the Department of Commerce.

The following is quoted from a letter under date of April 9, 1917, from the Hon. W. C. Redfield, Secretary, Department of Commerce:

> "The Government offices have been particularly crowded with official work during the past few months and the translation has not been given the attention which it might otherwise have received. Matters are now in such shape, that the first printed specifications should be issued within a few weeks and it is hoped that all may be available before the June meeting."

Possibilities of Assistance on the Part of the Society to the National Government during the War.—In Circular No. 116 to the members, issued in April, 1917, it was announced that the following letter had recently been addressed to the President of the United States by the President of the Society:

> HONORABLE WOODROW WILSON,
> *President of the United States,*
> *Washington, D. C.*
>
> *Dear Sir:*
>
> On behalf of the Executive Committee of the American Society for Testing Materials, a national organization of some twenty-one hundred members, I hereby pledge to you their whole-hearted desire and purpose to tender the organization of this Society, through its numerous technical committees, and any other agencies that they may be able to create or command, towards the loyal support of the United States Government in the present national crisis.

I am enclosing a statement containing more detailed reference to the Society, and its present organization, with an accompanying copy of its membership list, etc., for the year 1916.

Awaiting your further commands, I am

Very respectfully,
(Signed) A. A. STEVENSON,
President.

In connection with the detailed information concerning the Society which accompanied this letter, the suggestion was made that "the Society might find an important field of usefulness to the United States Government in the present emergency through a plan of cooperation (*a*) in an advisory way in relation to specifications for materials, and (*b*) in a practical way in the inspection and testing of materials."

As stated in Circular No. 116, the Executive Committee is not prepared to offer definite recommendations in this important matter. It has endeavored, however, to keep in as close touch with the situation as possible, and the members of the Society may feel assured that they will be promptly advised of any important developments affecting the Society.

As an illustration of the services the Society may be able to render the Government in the present emergency, it may be stated that during the past year, at the solicitation of the Naval Fuel Oil Board, valuable technical information was furnished that Board, through Mr. P. H. Conradson, Vice-Chairman of Committee D-2 on Lubricants, and Mr. Sanford E. Thompson, Chairman of Committee C-9 on Concrete and Concrete Aggregates, concerning the practicability of storing fuel oil in concrete tanks.

Joint Conference Committee with the American Society of Mechanical Engineers.—The Executive Committee wishes to announce that a Joint Conference Committee has been appointed, consisting of three representatives from the American Society of Mechanical Engineers and three representatives from this Society, to consider questions affecting the "Boiler Code" of the American Society of Mechanical Engineers in which the two societies are mutually interested. The personnel of this committee is as follows:

Representing the A.S.M.E.	*Representing the A.S.T.M.*
D. S. Jacobus,	F. J. Cole,
S. F. Jeter,	C. F. W. Rys,
W. F. Keisel.	C. D. Young (*Chairman*).

Tests of Steel Columns.—About ten years ago a program of tests to be made at Watertown Arsenal on steel columns was drawn up under the auspices of a committee of the Society, which included the Commanding Officer and the Engineer of Tests of the Arsenal. This program was approved by the Chief of Ordnance, U. S. A., and some of the columns included in the program were tested. The results of these tests were reported by Mr. J. E. Howard, then Engineer of Tests, Watertown Arsenal, in two papers contributed to the Proceedings of the Society.[1] Owing to lack of adequate appropriations for this work, its discontinuation became necessary some years ago. During the past year the untested columns in this program were shipped to the Bureau of Standards, Washington, for the use of the committees on steel columns of the American Society of Civil Engineers and the American Railway Engineering Association.

Respectfully submitted on behalf of the Executive Committee,

A. A. STEVENSON,
President.

EDGAR MARBURG,
Secretary-Treasurer.

EDITORIAL NOTE.

The proposed amendments of the by-laws referred to in this report were adopted by letter ballot of the Society on August 15, 1917. The by-laws in their amended form appear on pages 7–14 of the 1917 Membership Pamphlet.

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[1] Vol. VIII, p. 336 (1908); and Vol. IX, p. 413 (1909).

APPENDIX.

REGULAR MEETING, June 28, 1916.—Hotel Traymore, Atlantic City, N. J. Present: Mr. A. A. Stevenson, President; Genl. W. H. Bixby and Mr. S. S. Voorhees, Vice-Presidents; Mr. A. W. Gibbs and Mr. Mansfield Merriman, Past-Presidents; Mr. W. H. Bassett, Mr. John Brunner, Mr. W. K. Hatt and Mr. J. A. Mathews, Members of Executive Committee.

On motion the Secretary-Treasurer was authorized to appoint an "Assistant to the Secretary" at a salary of $1200 per annum.

The recommendation contained in the annual report of Committee C-1 on Cement, relative to the title— "American Specifications and Methods of Tests for Portland Cement"—of the proposed revised specifications for Portland cement was then discussed. Since Committee C-1 was in session at that time, it was decided to invite Mr. F. W. Kelley of that committee, and a member of the outgoing Executive Committee, to participate in this discussion. On Mr. Kelley's response to this invitation the report of Committee C-1 was further considered, which resulted, on motion, in the following action, which was transmitted to the committee through Mr. Kelley:

> "That the recommendation in the annual report of Committee C-1, 'that the proposed revised specifications for Portland cement be given the title American Specifications and Methods of Tests for Portland Cement' be not approved.
>
> "That it is the sense of the Executive Committee that the purpose which Committee C-1 has in view in making this recommendation might be covered by a footnote to the title of the specifications reading about as follows:
>
> "These specifications are the result of several years' work of a special committee representing the United States Government Departmental Committee, the Board of Direction of the American Society of Civil Engineers, as well as Committee C-1 of the American Society for Testing Materials."

The Secretary-Treasurer reported that favorable action had been taken on 133 new applications for membership; that two members had resigned; that the Society had suffered the loss by death of two members, making the total membership in the Society on June 28, 1916, *2071*.

Correspondence with Mr. C. E. Skinner, Chairman of Committee A-8 on Cold-Drawn Steel, was presented, recommending the merging of that committee with Committee A-1 on Steel, from which it appeared that a letter ballot of the committee on the proposed merger had resulted in 7 affirmative and 3 negative votes, with 3 members not voting. This correspondence had been referred by the Secretary-Treasurer to Committee A-1 for consideration. The Advisory Committee of Committee A-1 had, by unanimous action, approved the proposed merger, with the understanding that those members of Committee A-8, who are not now members of Committee A-1, shall be invited to membership on Committee A-1, with a view of serving on the subcommittee on cold-drawn steel. On motion, it was decided to approve the proposed merger on that basis.

Correspondence with the Naval Fuel Oil Board was presented in which advice was solicited concerning the practicability of storing fuel oil in concrete tanks.

On motion it was decided to refer this correspondence to Mr. S. E. Thompson, Chairman of Committee C-9 on Concrete and Concrete Aggregates, and Mr. P. H. Conradson, Vice-Chairman of Committee D-2 on Lubricants, with the understanding that their recommendations should be sent to the Secretary-Treasurer and that the latter should confer with the President before forwarding the information to the Naval Fuel Oil Board.

Correspondence with the National Lumber Mfrs. Association, suggesting the desirability of creating a new committee on fire resistance of wood was, on motion, referred to Committee D-7 on Timber, inasmuch as that committee now has a sub-committee on the fireproofing of timber.

On motion it was decided to announce the following special prices for Vols. I–XII of the Proceedings:

	Members	*Non-Members*
In paper binding........................	$25	$30
In cloth binding.........................	30	35
In half-leather binding..................	35	40

It was also decided that the present published prices for single volumes shall remain unchanged, as well as the present prices for Vols. XIII, XIV and XV.

It was agreed that a reserve stock of 5 copies each of Vols. I and III, the present stock of which is now 37 and 36 copies respectively, shall be withheld from sale, and that these 5 copies shall be disposed of only by action of the Executive Committee.

The following resolution, introduced by Mr. Henry M. Howe at the fourth session of the annual meeting, was by action at that session referred to the Executive Committee for its consideration:

> "Recognizing the confusion, inconvenience, and loss of time and efficiency occasioned by the lack of uniformity in recording temperatures in this country; and recognizing further that the Centigrade scale is much simpler and more convenient than the Fahrenheit scale and is the present standard in all other countries except Great Britain, and is also in general use among scientific men throughout the world:
>
> "It is the sense of this meeting of the American Society for Testing Materials that the efforts being made to obtain legislation requiring the use of the Centigrade scale in all future Government publications should be heartily approved."

It was decided to refer the resolution back to the Society at the fifth session with the statement that it has the approval of the Executive Committee.

SPECIAL MEETING, August 7, 1916.—United Engineering Building, New York City. Present: Mr. A. A. Stevenson, President; Mr. S. S. Voorhees, Vice-President; Mr. Mansfield Merriman, Past-President; Mr. J. H. Gibboney, Member of Executive Committee; Mr. Edgar Marburg, Secretary-Treasurer; and, on invitation, Mr. R. S. Greenman, Chairman of Committee C-1 on Cement.

The President stated that this special meeting had been called for the consideration of the form of title for the Revised Standard Specifications and Tests for Portland Cement.

After considerable discussion, in which Mr. Greenman participated as the representative of Committee C-1, it was moved that no departure be made from the established practice of the Society in the title for the Revised Standard Specifications and Tests for Portland Cement; and that this action be taken without prejudice to the subsequent consideration of the addition of a footnote to the title, or at the bottom of the first page of these specifications, nor to the form of such a footnote. This motion was seconded and carried by a unanimous vote.

It was also decided by unanimous vote to omit the words "Methods of" in the proposed title, as not being in agreement with the established practice of the Society, the approved form of title being "Standard Specifications and Tests for Portland Cement."

REGULAR MEETING, October 10, 1916, 2 P. M.—Engineers' Club, Philadelphia. Present: Mr. A. A. Stevenson, President; Mr. A. W. Gibbs, Past-President; Mr. S. S. Voorhees, Vice-President; Mr. W. H. Bassett, Mr. J. H. Gibboney, Mr. G. W. Thompson, Members of Executive Committee; Mr. Edgar Marburg, Secretary-Treasurer.

The Secretary-Treasurer reported that favorable action had been taken on 43 new applications for membership; that two members had resigned; and that the Society had suffered the loss by death of two members, making the total membership in the Society on September 30, 1916, *2110*.

The following recommendations of Committee E-5 on Standing Committees, relating for the most part to changes in and additions to the Regulations Governing Standing Committees, were presented and formally approved:

(The page references in the following refer to the 1916 Membership Pamphlet.)

1. Page 177, following the title of Committee E-5 insert the note: "This committee consists of the chairmen of all standing committees or representatives designated by the respective chairmen.

2. Page 179, in the note following the title insert after the word "in," in the third line, the words "the Executive Committee and"

3. At the end of the note referred to in the previous paragragh add: "and (3) that proposed changes in these Regulations thus adopted shall be announced in the next circular to members and become effective from the date of issue of that circular."

4. Page 181, in the section on "Proxies," after the words "voting power" add "or without voting power, if so specified."

5. Page 181, in the section on "Reports" substitute the following for the present section:

"*Reports.*" The reports of standing committees shall be presented at the annual meetings. The report of every sub-committee shall be made to the parent committee and not to the Society direct. If such a report is embodied wholly or in part in the report of the parent committee to the Society, the latter shall make definite references to such features in its own report and recommendations, if any, based thereon.

The report of a standing committee before its presentation at the annual meeting must first have been submitted to letter ballot of the committee and must have received the approval of the majority of those voting.

A statement of the following form shall (for the remainder of this paragraph adhere to present form).

6. Page 181, add the following new paragraph to the present section on "Permanent Organization":

"The meetings of committees and sub-committees shall be open only to their own members and to such visitors whose proposed invitation has been approved by the chairman."

7. Page 181, in the paragraph on "Sub-committees", add the following sentence:

"Sub-committees shall have no standing in the Society, except through their parent committees."

The semi-annual report of the auditors was presented and ordered spread on the minutes:

JOHN HEINS & CO.,
Public Accountants and Auditors,
Philadelphia.

July 18, 1916.

Mr. Edgar Marburg, Secretary-Treasurer,
American Society for Testing Materials,
Philadelphia, Pa.

Dear Sir:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended June 30, 1916, and report them to be correct, and that the accounts are in the same excellent condition as at our last examination.

We submit balance sheet as of June 30, 1916, as also a statement of operations for the six months then ended, schedules of accounts receivable, etc.

Respectfully submitted,
(Signed) JOHN HEINS & CO.

On motion the following prices, previously authorized by the President, for the book of A. S. T. M. Standards were approved: To non-members, $7.50; to members (extra copies) $5.

The following revised special prices to non-members for sets of Vols. I–XII of the Proceedings were approved, viz., $35, $40 and $45 for paper, cloth and half-leather binding respectively, as against the previous prices of $30, $35 and $40, this change being based on the fact that at the previous prices the discount of 20 per cent to libraries and dealers would make the net prices lower than those to members, the latter being $25, $30 and $35 respectively.

The following report of the tellers, Mr. H. C. Berry and Mr. G. C. Davies was presented relative to the results of the letter ballot following the annual meeting.

Proposed Amendment of the By-Laws:	Aye	Nay	Not Voting
Article I, Section 3	263	4	134
Article I, Section 4	280	4	117
Article III, Section 6	270	4	127
Article VI, Section 1	259	4	138
Article VI, Section 2	265	4	132
PROPOSED REVISION OF STANDARDS.			
(NOT AMENDED AT ANNUAL MEETING.)			
Standard Specifications for:			
1. Structural Steel for Bridges (A 7–15)	134	2	265
2. Structural Nickel Steel (A 8–14)	125	2	274
3. Structural Steel for Buildings (A 9–14)	126	2	273
4. Structural Steel for Locomotives (A 10–14)	119	2	280
5. Structural Steel for Cars (A 11–14)	121	2	278
6. Structural Steel for Ships (A 12–14)	112	2	287
7. Carbon-Steel Bars for Railway Springs (A 14–14)	121	2	278
8. Carbon-Steel and Alloy-Steel Forgings (A 18–14)	126	1	274
9. Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19–14)	111	3	287
10. Carbon-Steel Forgings for Locomotives (A 20–14)	112	1	288
11. Cold-Rolled Steel Axles (A 22–14)	97	2	302
12. Wrought Solid Carbon-Steel Wheels for Steam Railway Service (combination and revision of Specifications A 23–12 and A 24–12)	100	0	301
13. Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25–13)	94	0	307
14. Steel Tires (A 26–14)	102	0	299
15. Steel Castings (A 27–14)	134	2	265
16. Lap-Welded and Seamless Steel Boiler Tubes, Safe Ends and Arch Tubes (A 28–13)	99	0	302
17. Drain Tile (C 4–14)	90	0	311
18. Purity of Raw Chinese Wood Oil (D 12–15)	67	2	332
Standard Tests for:			
19. Penetration of Bituminous Materials (D 5–11)	84	5	312
20. Loss on Heating of Oil and Asphaltic Compounds (D 6–11)	89	1	301
Standard Methods for:			
21. Making a Mechanical Analysis of Sand or Other Fine Highway Material, except for Fine Aggregates Used in Cement Concrete (D 7–11)	117	7	277
22. Testing (E 1–15)	143	3	255

(AMENDED AT ANNUAL MEETING.)	Aye	Nay	Not Voting
Standard Specifications for:			
23. Quenched Carbon-Steel Track Bolts (A 50–15)	97	0	304
24. Quenched Alloy-Steel Track Bolts (A 51–15)	94	0	307
25. Automobile Carbon and Alloy Steels (A 29–15)	100	2	299
26. Boiler and Firebox Steel (A 30–14)	107	4	290
27. Lap-Welded Iron Boiler Tubes (A 38–12)	101	0	300
28. Specifications and Methods of Tests for Portland Cement (C 1–09). To become effective on January 1, 1917, if adopted	187	7	207

PROPOSED NEW STANDARDS.	Aye	Nay	Not Voting
(NOT AMENDED AT ANNUAL MEETING.)			
Specifications for:			
1. Carbon-Steel Bars for Vehicle and Automobile Springs	97	0	304
2. Silico-Manganese-Steel Bars for Automobile and Railway Springs	104	0	297
3. Chrome-Vanadium-Steel Bars for Automobile and Railway Springs	104	0	297
4. Helical Springs for Railways	81	1	319
5. Elliptical Springs for Railways	83	2	316
6. Alloy-Steel Forgings	114	3	284
7. Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars	94	3	304
8. Bare Concentric-Lay Copper Cable: Hard, Medium-Hard or Soft	39	1	361
9. High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity	35	0	366
10. Foundry Coke	72	0	329
Methods for:			
11. Sampling and Analysis of Pig and Cast Iron	110	0	291
12. Making a Mechanical Analysis of Broken Stone or Broken Slag, except for Aggregates Used in Cement Concrete	93	5	303
13. Making a Mechanical Analysis of Mixtures of Sand or Other Fine Material with Broken Stone or Broken Slag, except for Aggregates Used in Cement Concrete	96	6	299
14. Distillation of Bituminous Materials Suitable for Road Treatment	101	2	298
15. Sampling of Coal	130	2	269
(AMENDED AT ANNUAL MEETING.)			
Methods for:			
16. Laboratory Sampling and Analysis of Coal	128	2	271

Total number of legal votes cast....................... 401

The following proposed amendment of the by-laws, in pursuance of action at the recent annual meeting, was approved:

Art. III, Sec. 2. Add the following two sentences just before the last two sentences:

"Members of the Executive Committee shall be ineligible for appointment on the Nominating Committee. The members of the Nominating Committee for the previous year shall not be eligible for appointment on this committee for the immediately succeeding year."

In pursuance of a motion at the last annual meeting that the Executive Committee consider the creation of a committee on Standard Scales of Magnification for Microphotographs, it was, on motion, decided to authorize the creation of such a committee.

In the matter of a footnote on the first page of the revised Standard Specifications and Tests for Portland Cement, it was decided to authorize the printing of the following note directly after the title of the standard:

> "These specifications are the result of several years' work of a special committee representing a United States Government Departmental Committee, the Board of Direction of the American Society of Civil Engineers, and Committee C-1 on Cement of the American Society for Testing Materials."[1]

The proposed general plan of procedure on the part of the Joseph A. tHlmes Safety Association *in re* the Holmes Memorial, was submitted, and o was decided to authorize the Secretary-Treasurer to distribute such propaganda among the members of the Society with an accompanying statement to be prepared by Mr. A. W. Gibbs, the representative of the Society in that association.

The Secretary-Treasurer reported that the steel columns formerly embraced in the test program at Watertown Arsenal, conducted under the auspices of a committee on which the A. S. T. M. was largely represented, but which had not yet been tested, had been shipped to the Bureau of Standards for the use of the committees on steel columns of the American Society of Civil Engineers and the American Railway Engineering Association.

The action of the President in appointing a committee consisting of himself, *ex-officio*, the Secretary-Treasurer and Mr. J. A. Capp, as the representatives of the Society on a proposed Joint Conference on ways and means of bringing about cooperation in American engineering standards, proposed in a letter under date of August 7, from the Secretary of the American Institute of Electrical Engineers, was approved.

In connection with the consideration of the time and place for the next annual meeting, it was decided to give the membership of the Society an opportunity for individual expressions of preferences, and that final action be deferred pending the returns from this inquiry.

REGULAR MEETING, January 16, 1917.—United Engineering Building, New York City.—Present: Mr. A. A. Stevenson, President; Mr. A. W. Gibbs, Mr. Mansfield Merriman and Mr. A. N. Talbot, Past-Presidents; Genl. W. H. Bixby, Vice-President; Mr. W. H. Bassett, Mr. John Brunner, Mr. J. H. Gibboney and Mr. W. K. Hatt, Members of Executive Committee; Mr. Edgar Marburg, Secretary-Treasurer.

The Secretary-Treasurer reported that favorable action had been taken on 47 new applications for membership; that 26 members had resigned, and that the Society had suffered the loss by death of 3 members, making the total membership in the Society on December 30, 1916, *2128*.

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[1] **This note was subsequently amended by the addition, at the end, of the phrase, "in cooperation with Committee C-1."**

The semi-annual report of the auditors was presented and ordered spread on the minutes:

John Heins & Co.,
Public Accountants and Auditors,
Philadelphia.

January 4, 1917.

Mr. Edgar Marburg, Secretary-Treasurer,
American Society for Testing Materials,
Philadelphia, Penna.

Dear Sir:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 30, 1916; having previously made a similar audit and report for the preceding six months ended June 30, 1916, and at both audits found the accounts to be correct, and to be in their usual excellent condition.

We submit balance sheet as of December 30, 1916, as, also, a statement of operations for the twelve months then ended, schedules of accounts receivable, etc.

Respectfully submitted,

(Signed) John Heins & Co.

The analysis of the vote on letter ballot as to place and time for the next annual meeting was presented as follows:

Place:	Atlantic City	256	Washington	18
	Chicago	56	Pittsburgh	17
	New York	42	Scattering	64
	Total			453

Time: June, 276, of which 175 favored the last week, 40 the third week and 29 any week.

Voted that the 1917 annual meeting be held at Atlantic City during the last week in June, beginning Monday, June 25.

The following recommendation was presented on behalf of Committee E-5 on Standing Committees: That the present paragraph in the section on "Appointments," in the Regulations Governing Standing Committees, which reads:

"3. As a general policy, only one representative from a given firm, company, corporation, laboratory, or other institutions shall be eligible to independent membership on a given committee, although exceptions to this rule may be permitted at the discretion of the committee concerned. If the membership on the committee is held in the name of a firm, company, corporation, laboratory, or other institution, more than one representative may, at the discretion of the committee concerned, participate in its activities, with the understanding that such representatives shall jointly command only a single vote."

be replaced by the following:

"3. As a general policy, only one individual connected with a given firm, company, corporation, laboratory, or other institution shall be eligible to membership on a given committee, although exceptions to this rule may be permitted at the discretion of the committee concerned. In case two or more members of a committee are connected with the same firm, company, corporation, laboratory or other institution, they shall, when a division is demanded, jointly command only a single vote."

Voted that this recommendation be approved with the understanding that Committee E-5 be requested to consider the desirability of adding the phrase "or a letter ballot is taken" after the present phrase in the proposed new paragraph "when a division is demanded."

The report of the tellers—Mr. W. D. Lober and Mr. P. H. Wilson—on recommendations for appointments on the Nominating Committee for Officers, was presented in summary, the complete report being available in full detail for reference purposes.

Voted that in addition to the last three Past-Presidents, who are *ex-officio* members of the Nominating Committee, the following appointments on that committee be made:

Members.	*Alternates.*
Kelley, F. W.	Ashton, E.
Aertsen, G.	Shuman, J. J.
Colby, A. L.	Quimby, H. H.
Hunnings, S. V.	Walker, P. H.
Wille, H. V.	Hubbard, P.
Skinner, C. E.	Chapman, C. M.

NOTE.—Every member and alternate in this list had received six or more votes.

Voted that the Regulations Governing the Executive Committee be amended to the effect that from and after January 1, 1918, the traveling expenses of members of the Executive Committee, incidental to their attendance at meetings of that committee, except such meetings as may be held in connection with the Annual Meeting, shall be defrayed by the Society.

Voted that in future the Tentative Standards and Tentative Revisions of Standards be published collectively in paper binding; that they be omitted in the Proceedings, and that their publication separately be also continued.

In the matter of issuing a monthly or bi-monthly publication, on which final action had been deferred at the meeting held on April 11, 1916, till the end of the fiscal year 1916, it was voted as the sense of the Executive Committee that it was inexpedient.

Voted that the publication of preprints of the report of the Joint Committee on Concrete and Reinforced Concrete, if recommended by that committee, or by the A. S. T. M. Committee C-2 on Concrete and Reinforced Concrete, be left with power to the President and Secretary-Treasurer.

REGULAR MEETING, April 10, 1917.—Engineers' Club, Philadelphia Present: President A. A. Stevenson; Vice-Presidents Genl. W. H. Bixby and S. S. Voorhees; Past-Presidents A. W. Gibbs and Mansfield Merriman; Members of Executive Committee: W. H. Bassett, John Brunner, W. K. Hatt and G. W. Thompson; Secretary-Treasurer Edgar Marburg; and, by special invitation, Mr. R. S. Greenman, Chairman of Committee C-1 on Cement.

President Stevenson announced that Mr. R. S. Greenman, Chairman of Committee C-1 on Cement, had been invited to attend this meeting with a view of participating in the consideration of the question of the form of "Note" following the title of the Standard Specifications and Tests for Portland Cement.

Following a brief presentation of the history of this "Note," Mr. Greenman advanced certain considerations on behalf of Committee C-1. Thereupon, after a general discussion, it was voted, as the sense of the meeting, that the note following the title of these specifications be omitted entirely, and that the title itself be continued as at present in accord with the titles of the A. S. T. M. Standards in general.

The Secretary-Treasurer reported that favorable action had been taken on 101 new applications for membership; 56 members had resigned; 69 members had been dropped for non-payment of 1916 dues; and that the Society had suffered the loss by death of 2 members, making the total membership in the Society on April 1, 1917, *2102*.

On motion the following recommendations of Committee E-5 were approved:

1. "That no change be made in the existing recommendations regarding standard definitions of terms in the present 'Recommendations to Standing Committees' in the Regulations Governing Standing Committees.

2. "That the phrase 'or a letter ballot is taken' be *not* added in paragraph 3 of the Section on Appointments in the Regulations Governing Standing Committees." (For action taken at the last meeting of the Executive Committee see minutes of meeting January 16.)

The following communication, under date of April 9, 1917, from Hon. W. C. Redfield, Secretary, Department of Commerce, was presented:

"Referring to the matter of translation of specifications which were to be prepared and published by the Department, it is regretted that there has been so much delay involved. This has been caused by a combination of circumstances explained in previous letters. The first draft of the translation of all specifications has been completed. A number of them have been reviewed and it is anticipated that some will be sent to the printing office during the current week. The United States Steel Corporation is also making a translation of certain specifications and it is our desire to have the benefit of mutual comparison to avoid conflict of phraseology.

"The Government offices have been particularly crowded with official work during the past few months and the translation has not been given the attention which it might otherwise have received. Matters are now in such shape that the first printed specifications should be issued within a few weeks and it is hoped that all may be available before the June meeting."

The following nominations for officers on the part of the Nominating Committee were presented, and it was voted that they be brought to the notice of the membership at large as provided in the by-laws:

For President: Genl. W. H. Bixby.

For Vice-President: Edward Orton, Jr.

For Members of Executive Committee: J. A. Capp, W. F. M. Goss, W. M. Kinney, C. D. Young.

On motion it was voted to propose the following amendment of Section 3, Article II of the by-laws:

Strike out:

The terms of office shall begin at the time of this announcement, except that the retiring President shall continue as presiding officer of the sessions of the Society throughout the Annual Meeting. The President-elect shall be the presiding officer at any session of the Executive Committee that may be held after the announcement of his election.

Substitute:

The terms of office shall begin at the close of the Annual Meeting.

ADJOURNED MEETING, May 19, 1917.—United Engineering Building, New York City. Present: A. A. Stevenson, President; A. W. Gibbs and Mansfield Merriman, Past Presidents; S. S. Voorhees, Vice-President; J. H. Gibboney and G. W. Thompson, Members of the Executive Committee.

The President announced the purpose of the meeting: That the Secretary-Treasurer, Mr. Edgar Marburg, had been obliged to be away from his duties since May 8 on account of illness, and that on May 12 his physicians had ordered a cessation of all work for perhaps six months. The President further stated that the absence of the Secretary-Treasurer necessitated certain action on the part of the Executive Committee in order that the business of the Society may be carried on without interruption. He also stated that he had been at the office of the Society daily during the past week, looking after the interests of the Society, and that he would continue to do so as frequently as might be necessary.

On motion, the following resolution was adopted:

"*Resolved*, That the Executive Committee confirm the action of the Secretary-Treasurer in appointing C. L. Warwick Assistant to the Secretary, in pursuance of the following motion adopted at a meeting of the Executive Committee in Atlantic City, held at the Hotel Traymore, June 28, 1916:

"On motion the Secretary-Treasurer was authorized to appoint an Assistant to the Secretary at a salary of $1200 per annum, this being the salary now being paid Mr. Warwick, who has practically been acting in that capacity for some time."

The President called attention to the sum $1784.02, representing I.A.T.M. dues for 1915 paid by certain American members of that Association, and held in trust for them by the Society, these payments having been made prior to the following announcement by the International Association:

"The war has interrupted the activity of the Association. We have therefore for months been obliged to confine ourselves to the bringing of the work of the Sixth Congress to a conclusion by issuing a reprint of the Uniform Nomenclatures recommended by this Congress.

"As the Association has sufficient funds to cover the administrative expenses for a long time, we beg to inform you that no member will be called up for payment of his dues until the Council, after the change of the political situation, take further action. But non-payment will in no way interfere with membership."

This announcement was mailed to the members of the Society in April, 1915, concurrently with Circular to Members No. 96, in which it was stated, after calling attention to the above announcement by the I.A.T.M., that:

> "The Secretary-Treasurer has accordingly been instructed by the Executive Committee 'to notify those members whose dues in the International Association for the current fiscal year have already been paid, that their remittances will be held in trust pending the adjustment of this matter, but that payments will be refunded at any time on individual requests'."

The President stated that he had brought up this matter with a view of deciding whether it might not be considered advisable to return these subscriptions, in view of the apparent indefinite duration of the present war and the fact that this country had entered the conflict.

Voted that these dues be returned to the members from whom they had been received.

The President reported that the following letter had been sent to the President of the United States under date of April 16, and that this fact had been announced to the membership at large in Circular to Members No. 116, issued in April, 1917:

"HONORABLE WOODROW WILSON,
President of the United States,
Washington, D. C.

"*Dear Sir:*

"On behalf of the Executive Committee of the American Society for Testing Materials, a national organization of some twenty-one hundred members, I hereby pledge to you their whole-hearted desire and purpose to tender the organization of this Society, through its numerous technical committees, and any other agencies that they may be able to create or command, towards the loyal support of the United States Government in the present national crisis.

"I am enclosing a statement containing more detailed reference to the Society, and its present organization, with an accompanying copy of its membership list, etc., for the year 1916.

"Awaiting your further commands, I am

Very respectfully,
(Signed) A. A. STEVENSON,
President."

In connection with the detailed information concerning the Society which accompanied this letter, the suggestion was made that "the Society might find an important field of usefulness to the United States Government in the present emergency through a plan of cooperation (*a*) in an advisory way in relation to specifications for materials, and (*b*) in a practical way in the inspection and testing of materials."

The Assistant to the Secretary presented the following resolution on behalf of Committee A-1, which was adopted at the last meeting of that committee:

> "That Committee A-1 recommends to the Executive Committee that the present 'Procedure Governing the Adoption of Standards,' as contained in Article VI of the By-laws and in the Regulations Governing Standing Committees, be revised by eliminating the requirement that 'proposed amendments of existing standards . . . shall be printed . . . in the Pro-

ceedings under a section designated "Tentative Standards",' and substituting therefor the requirement that such proposed amendments shall be printed in the report of the Committee; no other changes in the procedure governing their adoption to be made."

The Assistant to the Secretary suggested the following revised wording of the second paragraph of Section 1, Article VI of the By-laws, which also forms part of the Regulations Governing Standing Committees, which provides, in addition to the above, for the following two features: (1) the printing of the Tentative Standards in separate pamphlet form; and (2) the adoption in the odd years of Tentative Standards which have been published for two years; the latter question having arisen in the editing of committee reports for the Annual Meeting (italics represent new matter):

> "Proposed new standards or proposed amendments of existing standards shall be presented at the Annual Meeting. At this meeting amendments may be made by a two-thirds vote of those voting. Proposed new standards, as presented or as amended, shall be *published* on two-thirds vote of those voting, *in a separate pamphlet entitled 'Tentative Standards,'* on which written discussions addressed to the appropriate committee shall be invited. *Proposed amendments of existing standards as presented or as amended shall be printed, on two-thirds vote of those voting, in the report of the appropriate committee.* If introduced in an even year such tentative standards *or proposed amendments of existing standards* shall be published for two years, and if introduced in an odd year they shall be published for one year. At the Annual Meeting in the next even year following their introduction, such tentative standards *or proposed amendments of existing standards* shall be subject to amendment by a two-thirds vote of those voting, and to reference by a like vote to letter ballot of the Society. A two-thirds vote of those voting shall be required for adoption. *If tentative standards, or proposed amendments of existing standards, introduced in an odd year are not referred to letter ballot in the next even year, they may be referred to letter ballot in the following odd year. In that case the above prescribed vote as to amendments, as to reference to letter ballot, and as to adoption shall remain unaffected.*"

Voted to refer this matter to Committee E-5 for consideration and advice.

In connection with the question of how the tentative standards should be published, referred to above, attention was called to the fact that the Executive Committee had decided at its meeting on January 16, 1917, to issue the tentative standards in future in a separate pamphlet entitled "Tentative Standards," and not in the Proceedings, notwithstanding the fact that the by-laws and regulations prescribe that they shall be published in the Proceedings.

Voted that the question of the publication of the tentative standards only in the Proceedings or as a separate publication be submitted to the Society at the approaching Annual Meeting for such action as may be taken pending the appropriate amendment of the by-laws.

REPORT OF COMMITTEE A-1
ON
STEEL.

Since the last annual meeting Committee A-1, which now numbers 110 as compared with 97 last year, has held two well-attended meetings in January and April, 1917, at which all of the recommendations which follow were submitted by the appropriate sub-committee and approved for reference to letter ballot of the committee.

Sub-Committees.—At the last annual meeting, Committee A-8 on Cold-Drawn Steel, at its own request, was merged by the Executive Committee with Committee A-1. A new sub-committee on Cold-Drawn Steel was therefore formed, on which are serving all of the members of the former Committee A-8. This sub-committee is now responsible to Committee A-1 for the two specifications of the Society for cold-drawn steel.

A new sub-committee on Deep-Drawing Steel Stock is in course of organization, making eighteen sub-committees of Committee A-1, including the Advisory Committee.

A special committee has been organized to harmonize, if possible, the bend test requirements in the various specifications for steel.

Recommendations.—The recommendations of the committee affecting standards and tentative standards, which will be referred to in greater detail later in the report, are briefly as follows:

I. PROPOSED REVISIONS IN STANDARDS.

The committee presents in Appendix I to this report certain proposed revisions in the Standards Specifications listed below. At the next annual meeting, the committee will recommend that these proposed revisions be referred to letter ballot of the Society for adoption as standard:

1. For Blooms, Billets and Slabs for Carbon-Steel Forgings (A 17–13);
2. For Carbon-Steel and Alloy-Steel Forgings (A 18–16);

3. For Quenched-and-Tempered Carbon-Steel Axles, Shafts, etc. (A 19–16);
4. For Quenched-and-Tempered Alloy-Steel Axles, Shafts, etc. (A 63–16);
5. For Lap-Welded and Seamless Steel Boiler Tubes, etc., for Locomotives (A 28–16);
6. For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52–15);
7. For Welded Steel and Wrought-Iron Pipe (A 53–15);
8. For Automobile Carbon and Alloy Steels (A 29–16);
9. For Boiler and Firebox Steel for Locomotives (A 30–16).

II. PROPOSED REVISIONS IN TENTATIVE STANDARDS.

The committee recommends that the following two specifications published in the Proceedings last year among the Tentative Standards be revised and continued as tentative for another year.

10. For Steel Tie Plates (A 67–16 T).

The proposed revisions in these specifications, which are referred to later under the heading "Steel Rails and Accessories," were such that it was deemed advisable to rewrite the specifications. A copy of the specifications in their proposed revised form is appended to this report.[1]

11. For Boiler and Firebox Steel for Stationary Service (A 70–16 T).

The proposed revision in these specifications is contained in Appendix I.

III. PROPOSED NEW TENTATIVE STANDARDS.

The committee recommends that the following specifications, which are appended to this report,[2] be published for one year among the Tentative Standards:

12. For Carbon Tool Steel.

The above recommendations have been referred to letter ballot of the committee, which consists of 110 members; 103 ballots have been cast, 7 members having refrained from voting. The analysis of the vote of the committee is given in the accompanying table.

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[1] See pp. 541–545.—ED.

[2] See pp. 562–563.—ED.

ANALYSIS OF VOTE OF COMMITTEE A-1 ON ITS RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS.

Items.	Affirmative.	Negative.	Not Voting.[1]
I. PROPOSED REVISIONS IN STANDARDS.			
1. For Blooms, Billets and Slabs for Carbon Steel Forgings (A 17-13)	80	1	22
2. For Carbon-Steel and Alloy-Steel Forgings (A 18-16)	81	1	21
3. For Quenched-and-Tempered Carbon-Steel Axles, Shafts, etc. (A 19-16)	71	1	31
4. For Quenched-and-Tempered Alloy-Steel Axles, Shafts, etc. (A 63-16)	70	1	32
5. For Lap-Welded and Seamless Steel Boiler Tubes, etc., for Locomotives (A 28-16)	62	1	40
6. For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52-15)	63	1	39
7. For Welded Steel and Wrought-Iron Pipe (A 53-15)	67	0	36
8. For Automobile Carbon and Alloy Steels (A 29-16)	64	2	37
9. For Boiler and Firebox Steel for Locomotives (A 30-16)	68	0	35
II. PROPOSED REVISIONS IN TENTATIVE STANDARDS.			
10. For Steel Tie Plates (A 67-16 T)	57	4	42
11. For Boiler and Firebox Steel for Stationary Service (A 70-16 T)	66	1	36
III. PROPOSED NEW TENTATIVE STANDARD.			
12. For Carbon Tool Steel	71	2	30

[1] In this column is recorded the number of votes cast as "not voting" on the various items.

Total number of ballots cast	103
Number of members who failed to vote	7
Total Membership	110

Present Tentative Specifications.—In addition to the two tentative specifications previously referred to, four other tentative specifications submitted by the committee last year were published among the Tentative Standards, as follows:

For Steel Track Spikes (A 65-16 T);
For Steel Screw Spikes (A 66-16 T);
For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68-16 T);
For Elliptical Springs for Automobiles (A 69-16 T).

The committee recommends that these specifications be continued as tentative.

The committee presents its recommendations in greater detail below. Owing to the diversity of the subjects involved, it has been deemed best to group these recommendations in the order of the respective sub-committees directly responsible for them, so that all questions pertaining to the various specifications for a given class of material will be found together.

STEEL RAILS AND ACCESSORIES (SUB-COMMITTEE I).

Proposed Revised Tentative Specifications.—The committee has prepared proposed revised Tentative Specifications for Steel Tie Plates with the recommendation that they be published as tentative for one year, to supersede the existing tentative specifications of that title. The principal changes proposed are as follows:

1. *Process.*—The use of Bessemer steel has been permitted.

2. *Physical Properties.*—The upper limit for tensile strength of material over $\frac{5}{8}$ in. in thickness has been omitted.

   A sliding scale for percentage of elongation has been adopted for both 2-in. and 8-in. specimens, with a minimum value specified in each case.

   The bend test has been omitted and requirements for reduction of area substituted.

3. Provision has been made for purchase under chemical requirements only, if the design of the tie plate does not permit of proper physical testing.

4. *Permissible Variations.*—The permissible variation in sheared length of plates with shoulders parallel to the direction of rolling has been changed from $\frac{1}{8}$ in. to $\frac{3}{16}$ in. For plates with shoulders perpendicular to the direction of rolling, permissible variations in the distances from the face of shoulder to the outside and inside ends of the plate have been added.

The specifications, in their revised form, are appended to this report.[1]

Report on Rail Situation.—A report on the progress during the past year in various phases of the rail situation is given in Appendix II to this report.

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[1] See pp. 541–545.—ED.

Specifications for Steel Ties.—In the report of the committee presented last year, it was stated that the question of specifications for steel ties would be considered during the coming year. The committee has deferred the preparation of these specifications for another year in the hope that then more information on this subject will be available.

STRUCTURAL STEEL FOR SHIPS (SUB-COMMITTEE III).

In the report of the committee presented last year it was stated that the consideration of special requirements for permissible variations in weight and thickness of sheared plates for ship use would be taken up during the coming year. It has been felt desirable, however, to permit ship builders to become acquainted with the permissible variations proposed and adopted last year, before proceeding with the preparation of special requirements for ship use.

STEEL REINFORCEMENT BARS (SUB-COMMITTEE V).

Two questions relating to steel reinforcement bars were referred to the committee for decision during the past year. The first question related to the use of electric steel in place of open-hearth steel billets under the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15–14). The committee ruled that electric-steel billets should be acceptable under these specifications. The committee does not think it desirable to make this single change in the specifications at this time and will recommend it for the consideration of the Society at some time when other more important changes may be in view.

The committee believes that electric steel may always be sold acceptably in place of open-hearth steel wherever the latter is specified in A.S.T.M. specifications.

The second question related to the acceptability, under specifications A 15–14 referred to above, of reinforcement bars manufactured from discarded steel axles. The committee ruled that such bars should not be considered as meeting the requirements of the specifications in question, since in these specifications test by heat lot is required, which is not practicable in the case of discarded steel axles.

STEEL BILLETS AND FORGINGS (SUB-COMMITTEE VI).

Specifications for Blooms, Billets and Slabs for Carbon-Steel Forgings (A 17–13).—Proposed revisions in these specifications are given in Appendix I, and have for their object, first, to include requirements for blooms, billets and slabs for alloy-steel forgings; and second, to revise the requirements for carbon and manganese for billets for carbon-steel forgings. The changes given in Appendix I are changes in substance as distinguished from form. The changes in the wording of the specifications necessitated by the proposed revisions will be considered by the committee during the coming year.

The committee has invited Committee A-4 on Heat Treatment of Iron and Steel to consider the following footnote which it is proposed to add to these specifications (see Appendix I) and to make such recommendations regarding a minimum temperature as it considers proper:

> "In selecting billets for making forgings of classes K, L, and M, it is suggested that the use of steel with relatively high carbon content will permit of the use of a high draw-back temperature and thus put the steel in its best physical condition for service, shock and similar conditions."

Specifications for Carbon-Steel and Alloy-Steel Forgings (A 18–16).—The revisions recommended in these specifications are given in Appendix I. The proposed deletion of the footnote to Section 7 (*b*) of these specifications, as well as of the Standard Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts and other Forgings for Locomotives and Cars (A 63–16), in which are given typical chemical compositions for alloy-steel forgings of classes K, L, and M, is considered advisable because the committee feels that it is undesirable at present to attempt to correlate the chemical and physical properties of these forgings. Moreover, the recommended chemical compositions for blooms, billets and slabs for alloy-steel forgings previously referred to will meet the requirements.

Proof Test of Finished Forgings.—In the Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts, etc., for Locomotives and Cars (A 19–16) and the Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts, etc., for Locomotives and Cars (A 63–16), provision is made for an impact proof test of all forgings unless otherwise specified by the purchaser, details of this test being subject to agreement between the manufacturer and purchaser. Certain information regarding three methods of proof testing are appended to the specifications as a guide in determining a proof test. Since the adoption of these specifications, certain slight changes in the methods of proof testing there described have been made, and the committee recommends that the appendix to these specifications be changed to the form given in Appendix I to this report.

The committee also presents in Appendix III to this report a discussion on "Calculation of Energy Expended in Bending a Beam" and recommends that it be printed in the Proceedings for information.

Specifications for Carbon-Steel Car and Tender Axles (A 21-14).—The committee can only report progress on the question of drop-test requirements for car and tender axles. Tests on 6 by 11-in. axles are now being made.[1]

Two questions relating to forgings were referred to the committee for decision during the year, as follows:

1. The elimination of chemical requirements from specifications for axles in which the drop test is specified. It is the opinion of the committee that the time has not yet arrived when the physical properties disclosed by the drop test can be used to give definite information as to the serviceability of an axle without knowing the chemical composition of the steel.

2. The committee was asked for an opinion regarding the annealing of bored forgings before or after boring. It is the opinion of the committee that the question of annealing before or after boring does not properly concern the specifications of the Society, and if either practice is desired or considered necessary in special cases, it should be subject to special agreement between the manufacturer and the purchaser. This question has been referred to Committee A-4 on Heat Treatment of Iron and Steel for any consideration that committee may desire to give it.

STEEL CASTINGS (SUB-COMMITTEE VIII).

The only question which has come before the committee during the past year with reference to steel castings was the desirability of preparing specifications for alloy-steel castings, and the committee has decided that it is undesirable at the present time to prepare such specifications.

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[1] See Addendum to this report, pp. 118–119.—ED.

STEEL TUBING AND PIPES (SUB-COMMITTEE IX).

Specifications for Lap-Welded and Seamless Steel Boiler Tubes, etc., for Locomotives (A 28-16).—The proposed revisions in these specifications are given in detail in Appendix I. The committee wishes here to direct attention to the following features:

1. The proposed revision in the flange test is designed to express the size of the flange as a percentage of the outside diameter of the tube, with a maximum limit, instead of as a fixed dimension of sizes between certain limits;

2. The proposed revision of the requirements for the flattening test will bring this test into agreement with that of the American Society of Mechanical Engineers, the Master Mechanics' Association and the Master Car Builders' Association;

3. It is proposed to adopt the Birmingham wire gage as standard, changing the decimal gage to conform, which involves slight changes in the table of standard weights.

Specifications for Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52-15).—The proposed revisions in these specifications are given in detail in Appendix I. These revisions provide for the following more important features:

1. The extension of the specifications to include all of the tubes, flues, superheater pipes, arch tubes, etc., used in stationary boilers;

2. The harmonizing of the requirements for the flattening test and the flange test with specifications for tubes for locomotives (A 28-16);

3. A formula for determining the test pressure when the pressures specified give a fiber stress greater than 16,000 lb. per sq. in.;

4. A table of standard weights of tubes similar to that contained in the specifications for tubes for locomotives;

5. A table of thickness for various sizes and pressures which agrees with the table formulated by the A.S.M.E. Boiler Code Committee.[1]

Specifications for Welded Steel and Wrought-Iron Pipe (A 53–15).—The proposed revisions in these specifications are given in detail in Appendix I and require no comment here beyond the statement that the revisions in the flattening test for steel pipe, Section 6, are proposed with a view of harmonizing the A.S.T.M. requirements with those of the Master Mechanics' and Master Car Builders' associations. Although this proposed new test has not yet been formally adopted by these associations, it was acceptable to their representatives at a joint meeting with Sub-Committee IX.

The recommended revision in the bend test, in so far as it affects wrought-iron pipe, has been approved by Committee A-2 on Wrought Iron.

AUTOMOBILE STEELS (SUB-COMMITTEE X).

The proposed revisions in the Standard Specifications for Automobile Carbon and Alloy Steels (A 29–16) given in Appendix I are designed to harmonize the chemical requirements for screw stock in these specifications with the requirements of the Standard Specifications for Cold-Drawn Bessemer and Open-hearth Steel Automatic Screw Stock (A 32 and A 54). The committee has formally advised the Society of Automobile Engineers that it will recommend these revisions for adoption as standard a year hence, and has requested that Society to consider the revision of their specifications as to the requirements for screw stock so that the specifications of the two societies may still agree.

BOILER STEELS (SUB-COMMITTEE XI).

The only recommendation which the committee has to make this year with reference to boiler steels is the proposed elimination of the requirement for copper in firebox steel for both locomotives and stationary service as given in Appendix I.

American Society of Mechanical Engineers' Boiler Code.—As announced in the report of the Executive Committee this year, a permanent joint conference committee of this Society and the American Society of Mechanical Engineers has been appointed for the purpose of considering all questions relating to the A.S.M.E. Boiler Code in which the two societies are mutually interested. Sub-Committee XI on Boiler Steel will cooperate with the A.S.T.M. representatives on the conference committee in the solution of questions having to do with boiler and firebox steel for stationary service; although the understanding is that Committee A-1 is not obligated by any action of the conference committee.

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[1] This table was not received in time to be presented with this report on the floor of the meeting; see Addendum to the report, pp. 119–120.—ED.

METHODS OF CHEMICAL ANALYSIS (SUB-COMMITTEE XII).

Test Ingots for Ladle Analysis.—Last year the committee presented a progress report on its investigations of test ingots for ladle analysis covering chemical and microscopic surveys. At this time, the committee can simply report that these tests have been continued during the past year.

METHODS OF PHYSICAL TESTS (SUB-COMMITTEE XIII).

Order of Reporting Physical Properties.—In its report last year, the committee stated that the order of reporting the various physical properties of steel would be considered during the coming year. The committee recommends that this order shall be as follows: Elastic limit, proportional limit, and yield point; tensile strength; percentage of elongation; and reduction of area; but that no change shall be made in the order in which references to these properties occur in the A.S.T.M. specifications.

The committee wishes further to report that the recommendations relative to the speed of testing in determining the yield point and tensile strength contained in the report of Committee E-1 to the Society this year, were presented by Sub-Committee XIII at the April meeting of Committee A-1 and were approved by the committee at that meeting.

TOOL STEEL (SUB-COMMITTEE XIV).

The formation of a sub-committee on tool steel was announced in the last report of the committee. Specifications for carbon tool steel have been drawn up and are appended to this report[1] with the recommendation that they be printed as tentative for one year.

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[1] See pp. 562-563.—ED.

COLD-DRAWN STEEL (SUB-COMMITTEE XV).

The proposed harmonizing of the chemical requirements for screw stock in the Specifications for Automobile Steels with the Specifications for Cold-Drawn Bessemer and Open-hearth Steel Automatic Screw Stock has already been referred to.

The committee further wishes to report that it does not believe there is sufficient necessity at the present time to justify the consideration of specifications for cold-drawn or cold-rolled steel shafting.

MISCELLANEOUS.

Revision of Pipe Threads.—In pursuance of instructions from the Executive Committee at the time of the formation of Committee E-3 on Revision of Pipe Threads, the report of Committee E-3 presented to the Society this year was referred to Committee A-1 for its consideration, and was unanimously approved by the committee at its April meeting.

Order of Reporting Chemical Compositions of Steel.—The committee reports that The Association of American Steel Manufacturers has approved the order for reporting the chemical compositions of steel recommended by the committee in its report last year, but has not taken as yet any final action on the recommendations of the committee relative to the number of decimal places to which certain elements should be reported.[1]

This report has been referred to letter ballot of the committee, which consists of 110 members, of whom 94 have voted affirmatively, 1 negatively, and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. D. YOUNG,
Chairman.

C. L. WARWICK,
Secretary.

EDITORIAL NOTE.

For Addendum to this report, see page 118.

For Discussion, see page 121.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 106 (1916).

APPENDIX I.

PROPOSED REVISIONS IN SPECIFICATIONS FOR STEEL AND STEEL PRODUCTS.

In this appendix are given in detail proposed revisions in certain Standard Specifications. At the next annual meeting, the committee will recommend that these proposed revisions be referred to letter ballot of the Society for adoption as standard in accordance with the provisions of the by-laws of the Society.

After the title of each specification is given its serial designation and page number in the 1916 book of A.S.T.M. Standards, where it appears in its present form.

BILLETS AND FORGINGS.

SPECIFICATIONS FOR BLOOMS, BILLETS AND SLABS FOR CARBON-STEEL FORGINGS: A 17–13 (page 138).

The following proposed revisions in these specifications are the changes in substance, as distinguished from form, which the committee wishes to recommend. The necessary changes in form and wording of the specifications will be considered during the coming year.

1. Insert the following chemical requirements for Billets for Alloy-Steel Forgings:

Carbon Ranges for all Types of Steel.—

0.10 – 0.20 per cent.
0.15 – 0.25 "
0.20 – 0.30 "
0.25 – 0.38 "
0.30 – 0.43 "
0.35 – 0.50 "
0.45 – 0.60 "

Other Elements shall be as Follows:

ELEMENTS CONSIDERED.	Nickel Steel.	Chrome-Nickel Steel.				Chrome-Steel.	Chrome-Vanadium Steel.
		1.00 - 1.50 per cent Ni.	1.50 - 2.00 per cent Ni.	2.75 - 3.25 per cent Ni.	3.00 min. per cent Ni.		
Manganese, per cent..	0.50 - 0.80	0.50 - 0.80[a]	0.30 - 0.60	0.45 - 0.75[a]	0.30 - 0.60	0.30 - 0.60	0.50 - 0.80[a]
Phosphorus, max., per cent...............	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max., per cent.	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Nickel, per cent......	not under 3.00	1.00 - 1.50	1.50 - 2.00	2.75 - 3.25	not under 3.00	....	....
Chromium, per cent...	....	0.45 - 0.75	0.90 - 1.25	0.60 - 0.95	not under 1.00	0.60 - 0.90	0.80 - 1.10
Vanadium, min., per cent...............	....	....	....	....	....	....	0.15

[a] When the steel is to be used for case-hardening purposes, the manganese should be specified not to exceed 0.50 per cent. When the minimum carbon specified is 0.35 per cent or over, the manganese range may be specified 0.30 - 0.60 per cent.

2. Append the following footnote to the specifications:

> "In selecting billets for making forgings of classes K, L and M, it is suggested that the use of steel with a relatively high carbon content will permit the use of a high draw-back temperature and thus put the steel in its best physical condition for service, shock and similar conditions."

3. (*a*) Change the carbon ranges given in the present specifications, which apply to billets for carbon-steel forgings, to read:

0.05 - 0.15 per cent.
0.15 - 0.25 "
0.20 - 0.30 "
0.25 - 0.40 "
0.30 - 0.45 "
0.35 - 0.50 "
0.40 - 0.55 "
0.45 - 0.60 "

(*b*) Change the manganese ranges to 0.50–0.80 per cent for all carbon ranges with the following note:

> "When the steel is to be used for case-hardening purposes, the manganese should be specified not to exceed 0.50

per cent. When the minimum carbon specified is 0.35 per cent or over, the manganese range may be specified 0.30–0.60 per cent."

SPECIFICATIONS FOR CARBON-STEEL AND ALLOY-STEEL FORGINGS: A 18–16 (page 141).

1. *Section 7 (b)*.—Omit the footnote to this section appearing at the bottom of page 143 of the 1916 book of A.S.T.M. Standards.

2. *Section 13 (a)*.—Strike out the words "in Classes A to I inclusive," making the section read as follows:

> "13. (*a*) If the results of the physical tests of any test lot of forgings do not conform to the requirements specified, the manufacturer may re-treat such lot one or more times and retests shall be made as specified in Section 12."

3. *Section 13 (b)*.—Omit.

SPECIFICATIONS FOR QUENCHED-AND-TEMPERED CARBON-STEEL AXLES, SHAFTS, AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS: A 19–16 (page 150).

SPECIFICATIONS FOR QUENCHED-AND-TEMPERED ALLOY-STEEL AXLES, SHAFTS, AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS: A 63–16 (page 164).

1. Replace the appendices[1] to these two specifications by the following:

APPENDIX.

As a guide in deciding on a proof test for quenched-and-tempered forgings, the following particulars regarding three established methods of testing are given.[2] These methods of proof testing are giving satisfactory results in practice.

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[1] See 1916 Book of A.S.T.M. Standards, pp. 157 and 171.

[2] For more detailed information concerning these methods of proof testing, see Report of Committee A-1 on Standard Specifications for Steel, Appendix IV, "Report on Proof Tests of Finished Forgings," *Proceedings*, Am. Soc. Test. Mats., Vol. XIV, Part I, p. 120 (1914). Also, Report of Committee A-1 for 1917.

The Pennsylvania Railroad Co. and the Standard Steel Works Co. require that all axles, shafts and similar forgings shall undergo an impact proof test on an M. C. B. drop-test machine, with supports 3 ft. apart center to center, two blows being struck with a tup weighing 1640 or 2240 lb. The forging is to have one of the points of support as near as possible to one end for the first blow and as near as possible to the other end for the second blow, the forging being turned 90 deg. on its longitudinal axis after the first blow The requirements as to height of drop given in the accompanying table are derived from the following formulas:

$$\text{For the 1640-lb. tup: } H = 0.01D^3$$

$$\text{For the 2240-lb. tup: } H = 0.0073D^3$$

in which H is height of drop in feet and D is diameter of the forging at the center in inches.

PROOF TESTS FOR QUENCHED-AND-TEMPERED FORGINGS.

Diameter, in.	PENNSYLVANIA RAILROAD CO.; STANDARD STEEL WORKS CO. Supports 3 ft. Center to Center, Carried on M. C. B. Drop-Test Machine.		NEW YORK CENTRAL LINES, Rigid Supports 5 ft. Center to Center. CARNEGIE STEEL CO., Rigid Supports at Ends of Forgings.
	Height of Drop, ft. and in.		
	1640-lb. Tup.	2240-lb. Tup.	Energy of Blow, ft-lb.
4½	0 ft. 11 in.	....	700
5	1 " 3 "	....	900
5½	1 " 8 "	1 ft. 2 in.	1 200
6	2 " 2 "	1 " 7 "	1 700
6½	2 " 9 "	2 " 0 "	2 500
7	3 " 5 "	2 " 6 "	3 500
7½	4 " 3 "	3 " 1 "	4 700
8	5 " 1 "	3 " 8 "	6 000
8½	6 " 2 "	4 " 6 "	7 500
9	7 " 3 "	5 " 3 "	9 000
9½	8 " 7 "	6 " 3 "	10 000
10	10 " 0 "	7 " 4 "	11 000
10½	11 " 7 "	8 " 6 "	12 000
11	13 " 5 "	9 " 10 "	13 000
11½	15 " 3 "	11 " 1 "	14 000
12	17 " 4 "	12 " 8 "	15 000

The New York Central Lines and the Carnegie Steel Co. require that forgings shall be submitted to an impact proof test by having them carried on rigid supports and struck one blow at the center by a tup delivering the number of foot-pounds shown in the accompanying table. The New York Central Lines place the supports 5 ft. apart center to center, while the Carnegie Steel Co. places the supports as near as possible to the ends of the forgings.

2. In Section 7 (*b*) of Specifications A 63, omit the footnote, as recommended above for Specifications A 18.

TUBES AND PIPE.

SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL BOILER TUBES, BOILER FLUES, SUPERHEATER PIPES, SAFE ENDS AND ARCH TUBES FOR LOCOMOTIVES: A 28–16

(page 206).

1. Change the title to read:

> "Standard Specifications for Lap-Welded and Seamless Steel Boiler Tubes for Locomotives."

2. Insert the following new Section 1 entitled "Scope," and renumber all of the remaining sections:

> "1. These specifications cover lap-welded and seamless steel boiler tubes, boiler flues, superheater pipes, safe ends and arch tubes for locomotives."

3. *Section 2.*—Change the manganese requirement from "0.30–0.50 per cent," to "0.30–0.60 per cent."

4. *Section 4* (*a*).—Change from its present form, namely:

> "4. (*a*) For all tubes except superheater pipes, a test specimen not less than 4 in. in length shall have a flange turned over at right angles to the body of the tube, without showing cracks or flaws. This flange, as measured from the outside of the tube, shall be ⅜ in. wide for tubes 2½ in. or under in outside diameter, and ½ in. wide for tubes over 2½ in. in outside diameter.",

TABLE I.—STANDARD WEIGHTS.

LAP-WELDED AND SEAMLESS STEEL BOILER TUBES FOR LOCOMOTIVES.

INCLUDING SAFE ENDS, ARCH TUBES AND LARGE BOILER TUBES.

THICKNESS.		WEIGHT, LB. PER FT. OF LENGTH. Outside Diameter, in.													
In.	B. w. g.	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{4}$	$5\frac{3}{8}$	$5\frac{1}{2}$	6
0.095	13	1.679	1.806	1.932	2.186	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.109	12	1.910	2.055	2.201	2.492	2.783	3.365	.....	.....	.....	.....	.....	.....	.....	.....
0.120	11	2.089	2.249	2.409	2.729	3.050	3.691	4.331	.....	.....	.....	.....	.....	.....	.....
0.134	10	2.312	2.491	2.670	3.028	3.386	4.101	4.817	5.532	.....	.....	.....	.....	.....	.....
0.148	9	2.532	2.729	2.927	3.322	3.717	4.508	5.298	6.088	6.879	7.669	8.064	8.262	8.459	9.250
0.165	8	.....	.....	.....	.....	4.114	4.995	5.877	6.758	7.639	8.520	8.960	9.181	9.401	10.282
0.180	7	.....	.....	.....	.....	4.460	5.421	6.382	7.343	8.304	9.266	9.746	9.987	10.227	11.188

SMALL SUPERHEATER PIPES.

SEAMLESS ONLY.

THICKNESS.		WEIGHT, LB. PER FT. OF LENGTH. Outside Diameter, in.											
In.	B. w. g.	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{5}{8}$
0.095	13	0.537	0.601	......	......	......	......	......	......	......	......	......	......
0.109	12	......	......	0.746	0.818	......	......	......	......	......	......	......	......
0.120	11	......	......	......	......	0.967	1.047	1.127	......	......	......	......	......
0.134	10	......	......	......	......	......	......	......	1.597	1.776	1.865	1.954	2.133
0.148	9	......	......	......	......	......	......	......	1.741	1.939	2.038	2.137	2.334

to read:

> "5. (*a*) For all tubes under 6 in. in diameter and having a thickness less than 9 per cent of the outside diameter, a test specimen shall have a flange turned over at right angles to the body of the tube without showing cracks or flaws. This flange, as measured from the outside diameter of the top, shall not be less than 15 per cent of the outside diameter, but the flange shall in no case exceed ½ in. in width."

5. *Section 5.*—Change to read as follows by the insertion of the italicized words and the omission of the words in brackets:

> "6. (*a*).—For all tubes except superheater pipes, a test specimen *3 in.* [4 in.] in length shall stand flattening [or hammering] until the [inside of the] walls are in contact, without *showing cracks or flaws.* [cracking at the edges or elsewhere.] For lap-welded tubes, care shall be taken that the weld is not located at the point of maximum bend."
>
> "(*b*).—For superheater pipes, a test specimen *3 in.* [4 in.] in length shall stand flattening [by pressure or hammering] until the distance between the inside of the walls is equal to twice the thickness of the *wall,* [material] without *showing cracks or flaws.* [cracking at the edges or elsewhere.]

6. *Section 11.*—Replace the present Table I of Standard Weights by the accompanying Table I.

Specifications for Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service: A 52–15 (page 211).

1. Add the following new Section 1 entitled "Scope," and renumber all of the remaining sections:

> "1. These specifications cover lap-welded and seamless steel and wrought-iron boiler tubes, boiler flues, superheater pipes, safe ends and arch tubes for stationary service."

2. *Section 2* (*a*).—Change the manganese requirement from "0.30–0.50 per cent" to "0.30–0.60 per cent."

3. *Section 4 (a).*—Change from its present form, namely:

> "4. (*a*) A test specimen not less than 4 in. in length shall have a flange turned over at right angles to the body of the tube, without showing cracks or flaws. This flange, as measured from the outside of the tube, shall be $\frac{3}{8}$ in. wide for steel and $\frac{5}{16}$ in. wide for iron tubes.",

to read:

> "5. (*a*) For all tubes under 6 in. diameter and having a thickness less than 9 per cent of the outside diameter, a test specimen shall have a flange turned over at right angles to the body of the tube without showing cracks or flaws. This flange, as measured from the outside diameter of the tube, shall not be less than 10 per cent of the outside diameter for wrought-iron nor less than 15 per cent of the outside diameter for steel tubes, but the flange shall in no case exceed $\frac{1}{2}$ in. in width."

4. *Section 5.*—Change this section to read as follows by the insertion of the italicized words and the omission of the words in brackets:

> "6. (*a*) *For all tubes except small tubes and superheater pipes on which the flange test is not required*, a test specimen 3 in. in length shall stand *flattening* [hammering flat] until the [inside walls are brought parallel and separated by a] distance *between the inside of the walls is* equal to three times the *thickness of the wall*, [thickness,] without showing cracks or flaws. *For* [In the case of] lap-welded tubes, the test shall be made with the weld at the point of maximum bend.
>
> "(*b*) *For small tubes and superheater pipes on which the flange test is not required, a test specimen 3 in. in length shall stand flattening until the distance between the inside of the walls is equal to twice the thickness of the wall, without showing cracks or flaws.*"

5. *Section 6.*—Change to read as follows by the insertion of the italicized words:

> "7. Tubes under 5 in. in diameter shall stand an internal hydrostatic pressure of 1,000 lb. per sq. in., and tubes 5 in.

or over in diameter shall stand an internal hydrostatic pressure of 800 lb. per sq. in.; *provided that the fiber stress does not exceed 16,000 lb. per sq. in., in which case the test pressure shall be determined by the following formula:*

$$P = \frac{32{,}000\, t}{D}$$

in which P = the pressure in pounds per square inch, t = the thickness of wall in inches, and D = the inside diameter of tube in inches. Lap-welded tubes shall be struck near both ends, while under *the test* pressure, with a 2-lb. hand hammer or the equivalent."

6. Insert the following new sections following the present Section 10, which will be renumbered Section 11:

"IV. STANDARD WEIGHTS."

"12. The standard weights for tubes of various outside diameters and thicknesses, are as indicated in Table II.

7. *Section 12.*—Change to read as follows by the insertion of the italicized words and the omission of the words in brackets:

"14. The finished tubes shall be free from injurious defects *and distortion* and shall have a workmanlike finish. [They shall be practically free from kinks, bends and buckles.]

8. *Section 13.*—Change to read as follows by the insertion of the italicized words and the omission of the words in brackets:

"15. The name or brand of the manufacturer, the material from which it is made, whether steel or charcoal iron, and *the pressure in pounds at which the tube was tested,* ['Tested at 1000 lb.' for tubes under 5 in. in diameter. and 'Tested at 800 lb.' for tubes 5 in. or over in diameter,] shall be legibly stenciled on each tube."

9. *Section 15.*—Change the second sentence, namely:

"Tubes which fail in this manner will be rejected and the manufacturer shall be notified.",

TABLE II.—STANDARD WEIGHTS.

LAP-WELDED AND SEAMLESS STEEL BOILER TUBES FOR STATIONARY SERVICE.

INCLUDING SAFE ENDS, ARCH TUBES AND LARGE BOILER TUBES.

THICKNESS.		WEIGHT, LB. PER FT. OF LENGTH. Outside Diameter, in.																						
In.	B.w.g.	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{2}$	5	$5\frac{1}{4}$	$5\frac{3}{8}$	$5\frac{1}{2}$	6	7	8	9	10	11	12	13
0.095	13	1.679	1.932	2.186	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.109	12	1.910	2.201	2.492	2.783	3.074	3.365	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.120	11	2.089	2.409	2.729	3.050	3.370	3.691	4.011	4.331	4.652	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.134	10	2.312	2.670	3.028	3.386	3.743	4.101	4.459	4.817	5.175	5.532	6.248	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.148	9	2.532	2.927	3.322	3.717	4.112	4.508	4.903	5.298	5.693	6.088	6.879	7.669	8.064	8.262	8.459	.....	.....	.....	.....	.....	.....	.....	.....
0.165	8	.....	3.233	.....	4.114	4.555	4.995	5.436	5.877	6.317	6.758	7.639	8.520	8.960	9.181	9.401	10.282	12.044	13.807	.....	.....	.....	.....	.....
0.180	7	.....	.....	.....	4.460	4.940	5.421	5.901	6.382	6.863	7.343	8.304	9.266	9.746	9.987	10.227	11.188	13.110	15.033	16.955	.....	.....	.....	.....
0.203	6	.....	.....	.....	4.980	5.522	6.064	6.606	.....	.....	8.232	9.316	10.400	.....	.....	.....	12.568	14.736	16.904	19.072	21.240	.....	.....	.....
0.220	5	.....	.....	.....	5.357	5.944	6.531	7.119	.....	.....	.....	.....	11.231	.....	.....	.....	13.580	15.930	18.280	20.629	22.979	25.329	.....	.....
0.229	$4\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.788	.....
0.238	4	.....	.....	.....	5.749	6.385	7.020	7.656	.....	.....	.....	.....	.....	.....	.....	.....	14.646	17.188	19.730	22.271	24.813	27.355	.....	32.439
0.2485	$3\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31.188	.....
0.259	3	.....	4.815	5.507	6.198	6.890	7.582	8.273	8.965	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.179	26.945	29.711	.....	35.243
0.2715	$2\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.008	.....
0.284	2	.....	.....	.....	6.721	.....	8.238	8.996	9.754	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29.470	32.503	.....	38.569

NOTE.—Seamless tubes are at present not available above 6 in. in outside diameter.

TABLE II.—STANDARD WEIGHTS.—*Continued.*

Thickness.		Weight lb. per ft. of Length. Outside Diameter, in.																					
In.	B.w.g.	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{2}$	5	$5\frac{1}{4}$	$5\frac{3}{8}$	$5\frac{1}{2}$	6	7	8	9	10	11	12	13
0.292	$1\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.512	.....
0.300	1	.....	.....	.....	7.048	7.849	8.650	9.451	10.252	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.283	.....	40.69
0.320	$\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39.918	.....
0.340	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.791

NOTE.—Seamless tubes are at present not available above 6 in. in outside diameter.

SMALL SUPERHEATER PIPES.

SEAMLESS ONLY.

Thickness.		Weight, lb. per ft of Length. Outside Diameter, in.											
In.	B. w. g.	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{5}{8}$
0.083	14	0.480	0.535	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.095	13	0.537	0.601	0.664	0.727	.....	.....	.....	.....	.....	.....	.....	.....
0.109	12	.....	.....	0.746	0.818	0.891	.....	.....	.....	.....	.....	.....	.....
0.120	11	.....	.....	.....	0.887	0.967	1.047	1.127	.....	.....	.....	.....	.....
0.134	10	.....	.....	.....	.....	1.060	1.149	1.239	1.597	1.776	1.865	1.954	2.133
0.148	9	.....	.....	.....	.....	.....	1.247	1.346	1.741	1.939	2.038	2.138	2.334
0.165	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.352	.....

to read:

> "Superheater pipes when properly manipulated shall stand all forging, welding and bending operations necessary for application without developing defects. Tubes or superheater pipes which fail in any of the above operations will be rejected, and the manufacturer shall be notified."

10. The committee recommends that the table of thicknesses for various sizes and pressures now being formulated by the A.S.M.E. Boiler Code Committee be included in the specifications.[1]

SPECIFICATIONS FOR WELDED STEEL AND WROUGHT-IRON PIPE: A 53–15 (page 215).

1. Insert the following new Section 1 on "Scope," and renumber all of the remaining sections:

> "1. These specifications cover 'standard' and 'extra strong' welded steel and wrought-iron pipe, but not 'double extra strong' pipe."[2]

2. *Section 4* (*a*).—Change the requirement for tensile strength of wrought-iron pipe from 45,000 to 40,000 lb. per sq. in.

3. *Section 6*.—Change from its present form, namely:

> "6. A section of steel pipe 6 in. in length shall be flattened until the maximum distance between the walls is equal to three times the thickness of the material, without developing cracks, except at the weld.",

to read:

> "7. (*a*) For sizes over 2 in. in diameter, a section of lap-welded steel pipe 6 in. long shall be flattened until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.
>
> "(*b*) For sizes over 2 in. in diameter, a section of butt-welded steel pipe 6 in. long shall be flattened until

---

[1] See Addendum to this report, pp. 119–120.—ED.

[2] See Addendum to this report, p. 120.—ED.

the distance between the plates is one-half the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks."

4. *Section 8* (*a*).—Change to read as follows by the insertion of the italicized words and the omission of the words in brackets:

> "9. (*a*) For steel pipe *2 in. or under in diameter*, a sufficient length of pipe shall bend cold through *90 deg.* [180 deg.] around a *cylindrical* mandrel the diameter of which is *15* [18] times the nominal diameter of the pipe, without developing cracks *at* [in] any portion, and without opening the weld."

5. *Section 14* (*a*).—Change the last sentence to read as follows by the insertion of the italicized words and the omission of the words in brackets:

> "For pipe *2 in. or over in diameter*, [to 6 in. inclusive,] the outside diameter shall not vary more than 1 per cent over *or* [nor more than $\frac{3}{64}$ in.] under the standard *size*.

SPECIFICATIONS FOR AUTOMOBILE CARBON AND ALLOY STEELS: A 29–16 (page 220).

Section 5.—In Table I, "Automobile Carbon Steels," change the present chemical requirements for screw-stock material, namely:

	DESIRED.	PERMISSIBLE RANGE.
Carbon	0.14	0.08 – 0.20 per cent
Manganese	0.55	0.30 – 0.80 "
Phosphorus	not over 0.12	.... "
Sulfur	....	0.06 – 0.12 "

to agree with the requirements for this material in the Standard Specifications for Cold-Drawn Bessemer Steel Automatic Screw Stock (A 32–14), and for Cold-Drawn Open-hearth Steel Automatic Screw Stock (A 54–15), as follows:

BESSEMER STOCK.	
Carbon	0.08 – 0.16 per cent
Manganese	0.60 – 0.80 "
Phosphorus	0.09 – 0.13 "
Sulfur	0.075 – 0.15 "

OPEN-HEARTH STOCK.

Carbon	0.15 – 0.25	per cent
Manganese	0.60 – 0.90	"
Phosphorus	not over 0.06	"
Sulfur	0.075 – 0.15	"

SPECIFICATIONS FOR BOILER AND FIREBOX STEEL FOR LOCOMOTIVES: A 30–16 (page 228).

Section 3.—Omit the copper requirement of "not over 0.05 per cent" for firebox steel.

Also, change the manganese requirement for firebox steel from "0.30–0.50 per cent" to "0.30–0.60 per cent."[1]

TENTATIVE SPECIFICATIONS FOR BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE: A 70–16 T.[2]

Section 3.—Omit the copper requirement of "not over 0.05 per cent" for firebox steel.

Also, change the manganese requirement for firebox steel from "0.30–0.50 per cent" to "0.30–0.60 per cent."[1]

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[1] See Addendum to this report, p. 120.—ED.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 429 (1916).

APPENDIX II.

THE RAIL SITUATION.

The study of rail failures and causes productive of failures have been continued during the last year.

The most interesting data on these investigations are contained in publications by the Interstate Commerce Commission and the American Railway Engineering Association.

The Interstate Commerce Commission in the "Report of the Chief of the Division of Safety covering the Investigation of an Accident which occurred on the Galveston, Harrisburg & San Antonio Railway near Iser, Texas, January 31, 1916," issued February 12, 1917, publishes results of the examination of a failed rail and subsequent elaborate and painstaking investigations conducted by the engineer-physicist Mr. James E. Howard on stresses in rails. The investigator points our attention especially to the necessity of acquiring more information upon the successive stages through which the metal in a rail passes from the time of fabrication until rupture is reached. His studies of initial stresses in rails, the effect of wheel loads, internal strains developed by these loads, depths of penetration of wheel effect, effect of repeated and alternating stresses, are dealt with extensively as contributory causes for the development of transverse fissures.

Furthermore, it is pointed out that the primitive properties of the steel in the state when fabrication is complete, such as elastic limit, tensile strength, elongation and reduction of area, do not admit of being used up to their maximum limits in actual construction, and that the possession of such properties, recognized as desirable in the primitive condition of the steel, does not constitute a safeguard against failure. Those factors should be determined which impair the properties of the material after it has been put into service, and such use be made of steel that its integrity will not be destroyed.

The report recommends strongly the development of information upon the actual fiber stresses endured by rails in service, and data upon the limiting number of repetitions of alternate stresses which a rail is capable of enduring.

The American Railway Engineering Association in their Bulletin No. 195 of March, 1917, publish the report made by Dr. P. H. Dudley on "Induced Interior Transverse Fissures in Heads of Two Types."

The author has made close investigations of the rail mill practices, and presents the claim that induced interior transverse fissures can only develop in the track from the effects of preceding causes in the manufacture of rails, and that they have not occurred in countless thousands of rail heads of physically homogeneous metal because they have not been affected by delayed transformation of the metal near the center of the head, and chemical or mechanical defects which induce loss of strength, initial strains and cause a physically non-ductile core of heterogeneous metal near the center of the head. Detail description is given of the two general types of internal fissures. The elimination of the conditions of manufacture, claimed as producing the described contributory causes and their effects, is recommended for the prevention of interior transverse fissures.

Rail Failures.—Bulletin No. 195 of the American Railway Engineering Association contains the report of Mr. M. H. Wickhorst on "The Rail Failure Situation."

The author reviews the general subject of rail failures, their types and causes and indicates remedies to be applied in the light of our present knowledge.

It is pointed out that rail failures result mostly from two general causes:

1. Defective interior conditions of the ingot, and
2. Longitudinal seams in the bottom of the base.

The improvement of the ingot, or the non-use of the upper part of the ingot, are called to the attention of the steel manufacturer as remedies for the first cause. Most complete elimination of base seams is also a problem to be solved by the manufacturer in order to prevent the second cause, but a strengthening of the base through proper design is also advocated in order to eliminate base failures. Proper maintenance of track, joint and rolling equipment are also mentioned as important in order to obtain best service and longest life out of the rail.

The annual reports of rail failures in the United States and Canada (of which a compilation is given in this report) indicate that there has been a gradual decrease in the average number of failures per 100 track miles in rails rolled in recent years, and hope is expressed by the author that we may see a continuous decrease in the number of failures in future years.

Effect on Rail of Defective Equipment and Improper Maintenance.—Up to the present time no reports of a systematic investigation of this important matter, which undoubtedly must have a marked effect on the rail failure situation, are available.

Service Stresses in Rails.—There are important investigations on the matter of rail and track stresses now being conducted by a joint committee of the American Railway Engineering Association and the American Society of Civil Engineers, but while several preliminary reports have appeared, at the present time a final report on this important matter has not been made.

Testing of Rails.—1. *The Quick Bend Test of Rails as a Substitute for the Drop Test.* An elaborate and careful investigation has been conducted by the Pennsylvania Railroad System to develop the possibilities of a quick bend test as an alternate or substitute for the present drop test. The results obtained on an experimental machine at Altoona have shown such encouraging results that a special machine has been designed and will be used in the near future at the different rail mills in order to obtain definite comparative data of physical properties indicated by this machine and the regular drop test. The results obtained will be checked by observation of the rails in service to determine if the analysis of test data is confirmed by the performance of the rails in the track.

2. *Check Analysis for Segregation.*—The practice of analyzing the finished rail and rejecting for excessive segregation has obtained on the Pennsylvania System, with respect to 100-lb. rail, for two years. Records of the service of these rails are being kept to ascertain whether the improvement thus gained is sufficient to warrant the additional cost.

Rail Sections.—There is a decided tendency towards the use of heavier rail sections. Rails up to 130 lb. per yd. have been ordered by one of the leading railroads in considerable quantities.

The Rail Committee of the American Railway Engineering Association has finally adopted standard sections for rails over 100 lb. per yd.

APPENDIX III.

CALCULATION OF ENERGY EXPENDED IN BENDING A BEAM.

These calculations are presented as information on the question of proof testing of finished forgings. Impact proof tests of forgings, the details being subject to agreement between the manufacturer and the purchaser, are specified in two of the Society's specifications, namely: Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19–16), and Standard Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63–16).[1]

The calculations given below show the energy necessary to stress axles of various sizes to a maximum fiber stress of 40,000 lb. per sq. in. on the assumption that the axle has perfectly rigid supports, and that there is no crushing of the metal at the point of impact of the tup or at the points of support. This calculation shows that the energy in the tup ordinarily used in proof testing is very greatly in excess of that required under the assumed rigid conditions.

In the case of a 10-in. axle the energy specified by the Pennsylvania Railroad Co. is 16,400 ft-lb., while the calculation shows that with perfectly rigid supports and no crushing of the metal only 523 ft-lb. would be needed to produce a maximum fiber stress of 40,000 lb. per sq. in. On the M. C. B. spring-supported drop-test machine with no crushing of metal, the energy required is approximately 10 per cent more than with perfectly rigid supports.

It is believed that the difference between the energy shown by calculation and the energy being actually used in practice, is due to the fact that in practice there is a very considerable crushing of the metal at the point of impact of tup and at the supports.

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[1] 1916 Book of A.S.T.M. Standards, pp. 150 and 164. For further information relative to proof-testing, see *Proceedings*, Am. Soc. Test. Mats., Vol. XIV, Part I, p. 120 (1914); also this report, pp. 99–101.

It is evident that the actual conditions cannot be expressed definitely enough to make them accessible to calculations, and it appears that the only way to arrive at a satisfactory proof test is by actual trial.

CALCULATIONS.

Consider a beam, having a depth of d inches and a section modulus of z cubic inches, bent by a force of F pounds acting midway between two supports l inches apart. If a deflection of h inches be produced and if the maximum fiber stress of S pounds per square inch does not exceed the elastic limit of the material, the theory of beams gives the following equations:

$$F = \frac{4Sz}{l} \quad \text{(1)}$$

$$h = \frac{Fl^3}{24\ Edz} \quad \text{(2)}$$

$$h = \frac{1}{6}\,\frac{Sl^2}{Ed} \quad \text{(3)}$$

in which E is the modulus of elasticity. From these equations the work done in bending the beam can be found. The force to be overcome during bending increases gradually from zero to F, the mean force being $\frac{1}{2}F$; the distance through which the force acts during bending in h inches. Hence, if W is the work in inch-pounds done in bending the beam.

$$W = \tfrac{1}{2}Fh = \tfrac{1}{3}\,\frac{S^2lz}{Ed} \quad \text{(4)}$$

In the case of a beam of circular section d inches in diameter,

$$z = \frac{\pi d^3}{32},$$

and the work done is

$$W = \frac{\pi}{96}\,\frac{S^2ld^2}{E} \quad \text{(5)}$$

From these equations have been calculated, and are shown in Table I, the deflection, the maximum force required to bend, and the work done during bending, for axles of 6, 8, 10 and 12 in. diameter, assuming that the maximum fiber stress is $S=40,000$ lb. per sq. in., that the modulus of elasticity is $E=30,000,000$ lb. per sq. in., and that the distance between supports is $l=36$ in.

TABLE I.—DEFLECTION, FORCE OF DEFLECTION AND WORK OF DEFLECTION FOR AXLES OF VARIOUS DIAMETERS CARRIED ON SUPPORTS 36 IN. APART AND STRESSED TO 40,000 LB. PER SQ. IN.

Diameter of Axle (d), in.	Maximum Deflection $\left(h=\frac{0.288}{d}\right)$, in.	Maximum Force Producing Deflection ($F=436d^3$), lb.	Work Done in Producing Deflection,		Energy in Pennsylvania Railroad Co. Proof Test ($W=16.4d^3$), ft-lb.
			$W=62.8d^2$, in-lb.	$W/12$, ft-lb.	
6..............	0.048	94 500	2 260	188	3 540
8..............	0.036	224 000	4 010	335	8 400
10..............	0.029	436 000	6 280	523	16 400
12..............	0.024	754 000	9 050	754	28 300

In the last column is added for comparison the energy specified by the Pennsylvania Railroad Co. as a proof test.

ADDENDUM

TO

REPORT OF COMMITTEE A-1.

At the regular meeting of Committee A-1 held in Atlantic City on Monday evening, June 25, 1917, which was attended by 33 members, the following amendments to the annual report of the committee were unanimously approved:

Proposed Revisions in Specifications for Carbon-Steel Car and Tender Axles (A 21–14).

The committee recommends that the following proposed revisions of the Standard Specifications for Carbon-Steel Car and Tender Axles (A 21–14) be published in the Proceedings of the Society:

1. Insert the following new Section 1 entitled "Scope," and re-number all of the remaining sections:

> "1. These specifications cover axles up to and including those $6\frac{1}{2}$ in. in diameter at the center. Axles over $6\frac{1}{2}$ in. in diameter at the center shall not be subject to the drop test, but may be purchased under the Standard Specifications for Carbon-Steel and Alloy-Steel Forgings (Serial Designation: A 18) of the American Society for Testing Materials.

2. Replace the present Section 5 by the following:

> "6. (*a*) The test axle shall be so placed on supports 3 ft. apart that the tup will strike it midway between the ends. It shall stand without fracture five blows from a tup of 2240 lb. falling from a height H, such that H in feet equals the square of the diameter of the axle at the center in inches, $H = d^2$. The axle shall be turned through 180 deg. after the first and third blows.
>
> "(*b*) The permanent set produced by the first blow shall not exceed that given by the following formulas, in

which L = length of axles in inches and d = diameter of axle at center in inches:

For axles over 65 in. in length:

$$\left(\frac{L}{1.9d}-\frac{d}{2}\right)+\tfrac{1}{2}\text{ in.}\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

For axles 65 in. or under in length:

$$\left(\frac{L}{1.9d}-\frac{d}{2}\right)+1\text{ in.}\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

"(*c*) The Master Car Builders' Association and the American Railway Master Mechanics' Association have adopted four standard sizes of axles, the requirements for which, based on the above formula (1), are given in the following table:

Size of Axle, in.	Journal Diameter at Center, in.	Height of Drop ft.	Number of Blows	Maximum Permanent Set, in.
$4\frac{1}{4}$ by 8	$4\frac{3}{4}$	$22\frac{1}{2}$	5	$7\frac{1}{2}$
5 by 9	$5\frac{3}{8}$	29	5	$6\frac{1}{4}$
$5\frac{1}{2}$ by 10	$5\frac{7}{8}$	$34\frac{1}{2}$	5	$5\frac{1}{2}$
6 by 11	$6\frac{7}{16}$	$41\frac{1}{2}$	5	$4\frac{3}{4}$

"(*d*) The maximum permanent set is the difference between the distance from the straight edge to the middle point of the axle measured before the first blow and the distance measured in the same manner after the blow. The straight edge shall rest only on the collars or ends of the axle.

"(*e*) The temperature of the test axle shall be between 40 and 120° F."

PROPOSED REVISIONS IN SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS BOILER TUBES FOR STATIONARY SERVICE (A 52–15).

The committee reports that the table of thicknesses for various sizes and pressures referred to in Appendix I to the report, page 108, has not yet been approved by the Boiler Code Committee of the American Society of Mechanical Engineers, and cannot therefore be included in the report. The committee recommends that when available this table be included in the specifications as a matter of information, either in the form of a footnote or an appendix.

PROPOSED REVISIONS IN STANDARD SPECIFICATIONS FOR WELDED STEEL AND WROUGHT-IRON PIPE (A 53–15).

The committee recommends that the following new Section 1 on "Scope" be published in the Proceedings with the other proposed revisions of these specifications. (See Appendix I to the report, page 108):

> "1. These specifications cover 'standard' and 'extra strong' welded steel and wrought-iron pipe, but not 'double extra strong' pipe."

PROPOSED REVISION IN SPECIFICATIONS FOR BOILER AND FIREBOX STEEL.

The committee recommends that the manganese requirement for firebox steel in the Standard Specifications for Boiler and Firebox Steel for Locomotives, and in the Tentative Specifications for Boiler and Firebox Steel for Stationary Service, be changed from "0.30–0.50 per cent" to "0.30–0.60 per cent." (See Appendix I to the report, page 110).

EDITORIAL NOTE.

The proposed revisions of the Standards referred to in the report as Nos. 1 to 9, pages 86 and 87, as well as those referred to in the Addendum to the report, were accepted for publication in the Proceedings.

The three proposed tentative specifications referred to in the report as Nos. 10 to 12, page 87, were accepted for publication among the Tentative Standards of the Society, and appear on pages 541–545 and 562–563.

DISCUSSION.

DISCUSSION ON SPECIFICATIONS FOR STEEL TIE PLATES.

CAPT. ROBERT W. HUNT.—I think perhaps I occupy the position of the unanimous minority in that negative vote on the proposed Tentative Specifications for Steel Tie Plates. As I understand it also, the desire is that full discussion shall be sent to the Secretary and placed on record. I think, however, it will be very unfortunate if these specifications, even though everybody else on the committee thinks differently from me, should go before the world as our—well, not recommended, but comparatively endorsed specifications, because I regard them as absolutely impractical and contrary to manufacturing practice, and the practice accepted by the railways of the country. The limit of variation in dimensions which is permitted is so absolutely contrary to practice that it would be very unfortunate, in my opinion, if this Society seemingly endorses it. **Capt. Hunt.**

I would therefore amend the motion to accept these specifications, by eliminating them from general acceptance by the Society as tentative.

MR. C. D. YOUNG (*Chairman of Committee A-1*).—The points raised by Captain Hunt have been considered by Sub-Committee I, which drafted these specifications, in at least two sessions. The manufacturers have agreed to the tolerances for rolling and punching as being good practice, and I believe the consumers who were present at these meetings agreed that these tolerances were about what they were getting. These questions, however, are open for further review by the committee. It seems to me that it would be unfortunate to eliminate these specifications as offered by the committee; it would be much better to continue them as tentative and let the committee consider the criticisms of Captain Hunt and make such recommendations next year as might seem desirable in view of the use of the requirements specified. **Mr. Young.**

CAPT. HUNT.—The specifications are not being used. We are inspecting thousands of tons of tie plates, and certainly not **Capt. Hunt.**

Capt. Hunt. according to these specifications. It is more and more becoming the practice of manufacturers, and permitted by consumers, that material which has been made for other purposes, but is adapted to this use, shall be accepted. Now you are making a provision that every heat shall be subjected to prescribed physical test. That is practically impossible and is absolutely not being done, and so far as our firm is concerned, in this committee meeting, we did not agree to the approval of these specifications. It is with great hesitancy I make this point, but I dislike to see us place ourselves in what I think is a false position, an impractical position. A practical position is what we are trying to reach.

Mr. Abbott. MR. F. E. ABBOTT.—I should like to endorse what Captain Hunt said about the extent of testing, that is, these specifications call for more testing than the users care for, and it is hardly wise to increase the work and possibly the rejections when it is really not desired. This modification of a test to every heat, I think, so far as Bessemer steel is concerned, was not thoroughly studied out at the time the specifications were considered. My impression is that the committee would not insist on the extent of testing that this would call for in connection with Bessemer steel.

Mr. Thackray. MR. G. E. THACKRAY.—It appears that up to the present time there have not been any special or rigid requirements for material of this character, and it almost seems from what has been said, that requirements are now suggested which enumerate too many and too severe tests when the use to which this material will be put is considered.

Mr. Moldenke. MR. RICHARD MOLDENKE.—Would Captain Hunt agree to a slight change in his amendment, referring the specifications back to the committee instead of eliminating them? This would seem to work out a little better.

Capt. Hunt. CAPT. HUNT.—I will accept that amendment.

Mr. Gibboney. MR. J. H. GIBBONEY.—Would not the adoption of the committee's recommendations simply mean that we would retain as a tentative standard for tie plates the essentials of the present tentative specifications and in addition provide in these new tentative specifications requirements for the harder tie plate that is now coming into quite general use? So far as the criti-

Mr. Gibboney. cism of excessive testing is concerned, a careful reading of this suggested new tentative form will reveal the fact that the test requirements are merely those normally specified. It is probably quite true that many consumers do waive many testing requirements in their specifications for such material; however, such procedure does not warrant us in assuming that to be good practice. The committee, recognizing that some consumers might desire to waive the physical testing and yet have some substantial information to indicate the quality of the material, have inserted a clause providing for carbon determinations as a basis for acceptance. Surely such an option should satisfy those desiring to reduce the testing to a minimum and could under no circumstances prove burdensome to the manufacturer. It is our judgment that these suggested specifications are a decided improvement over the existing tentative standards, and that they should be approved.

Mr. Shuman. MR. J. J. SHUMAN.—I think perhaps I was responsible for the long time that these tentative specifications occupied on the floor of two committee meetings; at least the objections that I brought up had much to do with the time it took to put the specifications into the shape that they are now. The specifications are not satisfactory to me in all respects, by any means, but I think I am perhaps in a better position to speak a good word for them at this time than any other member present, for, as I say, the opposition to its several peculiarities came from this direction. Now my idea of a tentative specification is that it is a document set up for criticism. We cannot get that criticism if we wipe it out of the publications of the Society. The way to obtain the views of all parties is to publish these specifications as tentative, inviting criticism; and I am sure that in view of the words that have been spoken here by Captain Hunt and by others, the committee responsible for these specifications will go over them carefully, point by point, so that by the time they are proposed as a standard, they will be in acceptable shape, workable in form, and satisfactory to both the producer and the consumer.

Capt. Hunt. CAPT. HUNT.—The vote of the committee shows that I perhaps will have to be satisfied, and I will be with the fact that a protest and objection have been registered. I still think it is a

Capt. Hunt. mistake for specifications which the committee itself admits are not satisfactory—even those who have spoken, I think, have all admitted that the specifications do not meet with their approval—to be issued at all until we do get them in a form which appeals to all parties. But I am not an obstructionist, and I stand ready to loyally abide the decision of the meeting.

[The vote on Captain Hunt's amendment was lost, and the original motion to accept the specifications as tentative was then carried.—ED.]

DISCUSSION ON SPECIFICATIONS FOR CARBON TOOL STEEL.

Mr. Coyle. MR. FRANCIS B. COYLE.—I think a clause should be inserted in the proposed Tentative Specifications for Carbon Tool Steel showing that the material can be rejected due to undue segregation, which has caused a great deal of trouble in the past few months.

Mr. Darke. MR. J. M. DARKE (*Chairman of Sub-Committee on Tool Steel*).—That subject was discussed at several meetings. The trouble is that we know of no way of stating quantitatively the excessive segregation. If we could find a way, we should be glad to insert such a requirement in the specifications.

Mr. Hoffman. MR. N. B. HOFFMAN.—I find in these specifications, by the crucible or electric furnace process all that is required is the chemical composition, namely carbon, manganese, phosphorus, sulfur and silicon, which I feel is not broad enough to satisfy many of the users of tool steels. I shall confine my remarks to the crucible process.

I do not know whether we are all familiar with the fact that there are really two processes of manufacturing crucible steel. By the old process, the manufacturer would use, we will say, 80 per cent of muck iron (puddled iron) which costs at the present time about $90.00 a ton to produce. In the other process a so-called melting bar is used exclusively, which is nothing more nor less than steel made possibly from all sorts of steel scrap with the sulfur and phosphorus eliminated by fluxing in a basic open-hearth furnace. The product is rolled and cut into suitable sizes, and charged into the crucible. This melting bar, I should say, can be produced at half the cost per ton of the muck iron. **Mr. Hoffman.**

Now, I am satisfied that the muck-iron process gives a better steel, and a better and tougher tool, which will do more work, and be more efficient in every way, than a tool made from the melting-bar process. The manufacturer using muck iron is at a disadvantage in the price difference to start with, and with the chemical specifications only being given, he has no recourse.

Mr. Darke. MR. DARKE.—We tried to introduce in these specifications a clause governing the amount of oxides and slag in the steel. I understand that the difference between steel made from a muck bar and steel made from this open-hearth melting bar is in the amount of oxides present; therefore, if there was a clause limiting the amount of oxides in the steel, we could probably distinguish between steels made by these two processes. The sub-committee, however, would not agree to include such a clause, as they felt that there is no good method of determining quantitatively the amount of oxides present. In the specifications of the company which I represent, there is a clause relating to oxides and slag determined microscopically; and we can determine the difference between highly oxidized steel and steel without oxides. There is a big difference in the steels, but I do not know of any way of stating it quantitatively, and no one on the sub-committee knew of any way. We should be glad to receive suggestions along this line.

Of course, in manufacturing by the electric process we do not expect muck bar to be used.

Mr. Young. MR. C. D. YOUNG (*Chairman of Committee A-1*).—The problem in writing specifications for tool steel, as I understand it, is a difficult one, and I believe these specifications represent real progress. A great many buyers of tool steel purchase the steel after the bar is made and perhaps warehoused, and there are no means of knowing, when the bar is offered for sale, by what process it has been produced. That in turn leads to the difficulty of specifying explicitly how the steel shall be produced, because there are no means available to the buyer of going back through the history of the steel when it is offered to him, as to its manner of production. These specifications also call for the

Mr. Young. electric process, which would not mean, as I understand it, the use of the muck bar; and for grade C, straight open-hearth steel may be used. These specifications are submitted only as tentative, and the committee intends to continue its work and to offer such changes as the art of testing and inspection may develop.

Mr. Devries. MR. R. P. DEVRIES.—I do not know how other people purchase carbon tool steel, but it seems to me that if the only specification that we are going to have is to divide carbon tool steel into classes A, B, C, D, etc., and state what the chemical composition is, the specifications might just as well be omitted entirely. There is absolutely no use in them. What should be done is to get in touch with our committee which has charge of Recommended Practice for Heat Treatment. Tool steel is not very often used until after it is heat treated, and unless it will conform to the requirements after it is heat treated, I do not care what the chemical composition is. If it has not the necessary strength in the form of a tool to resist the shock of actual work, and if it has not got the hardness to stand up on a job so that the teeth are not going to break, turn over, etc., it does not make any difference what the chemical composition is. The committee should write into the specifications some requirement as to the hardness of the tool in a hardened condition, and how it should behave when drawn into different states, that is to say, when drawn for one purpose or another. Then, too, I believe that important information in this connection may be furnished by the microscope. So far as the chemical requirements are concerned, they are entirely secondary. It is not difficult to get 1-per-cent carbon tool steel, but it is difficult to get it so that it will always perform as you want it to perform, and those troubles usually arise after steel which does not have proper physical qualifications, has been heat treated.

Mr. Darke. MR. DARKE.—I should like to say that that would be a very desirable specification, but a specification at the best is an agreement, a mutual agreement between the producers and the consumers. Now we could not get the producers to agree to qualities that the steel should have after it is hardened. They would claim that the steel was not hardened properly, that it was spoiled in the hardening, etc. I should like to hear from some of the producers on our sub-committee. I am sure that at our meetings they expressed opinions against including such requirements in the specifications. **Mr. Darke.**

Mr. Ehrenfeld. MR. C. H. EHRENFELD.—It seems to me that we have reached the point where we can hardly afford, as a Society, to go on record, even tentatively, with specifications that are so manifestily incomplete as these, by the admission of the members of the committee themselves. There have been one or two points brought forward as to their weakness, and the committee admits that they would be glad to include those points if they knew how, and they admit they do not know how. In other words, it is all well enough to have good tentative specifications, but it does seem to me that we should not publish specifications if they are not quite up to the standard of our usual tentative specifications.

I represent the purchasers of tool steel and am free to admit that I am on the chemical side; but I am also perfectly willing to admit that the chemical analysis does not always give the desired information in regard to tool steel. Manifestly, from the manufacturing point of view, one can get chemically the same material from two radically different starting points as to grade, one of them much cheaper than the other, and which will not stand up under heat treatment. It seems to me that while the committee has made a start, they have not gotten very far as yet in anything sufficiently definite, and it would be very much better, in the uncertain state of the case, to refer the proposed specifications back for another year before we go on record as accepting confessedly incomplete and weak tentative specifications.

Mr. Aertsen. MR. G. AERTSEN.—It seems to me that the committee is in a rather difficult position. One speaker wants them to specify the raw material that shall be used in the so-called crucible process; another wants the specification to disregard raw material analysis and everything else except the behavior of the tool. These specifications, as I read them, are specifications for tool steel, bar steel, not for the raw materials or for the treatment the materials are to receive before the bar of steel is made; and they are not specifications for tools. No manufacturer of bar steel can guarantee what a tool made from that bar of steel will do; it depends more on the treatment it gets afterward than upon its

Mr. Aertsen. composition. The manufacturer does not have anything to do with the treatment; you might as well expect the manufacturer of an axle who sells it in the rough condition to guarantee that when it is finished the journal will be of the proper diameter. It seems to me that the committee, who have certainly worked very hard, have made a start in the right direction and I do not like to see their work turned down just because they have not arrived at the goal or as near the goal as they very likely will arrive by this time next year.

Mr. Howe. MR. HENRY M. HOWE.—We have to crawl before we can walk, and in the nature of the case these specifications have to be produced and have to be improved from time to time. Now we know that this committee is very competent; we know that they have a very difficult question to deal with here. To give a complete specification that would guarantee the excellence of an object of crucible steel would be like specifying that the marble from a given quarry should produce a statue of a certain excellence. The excellence of the statue depends on the artist, nevertheless they may have a specification for marble which would be useful. It seems as if this committee has made such provisions as, in the nature of the case and with the knowledge before it, constitutes some advance. They give the buyer a certain standard to which he may hold the seller. That standard will be elaborated as years go on, but it is a standard, it is something, it is the first step. We should not say we shall not take the first step because we are not taking the whole. Isn't that the way we have proceeded from the beginning, by taking steps and making specifications as far and as fast as we can, and improving them from year to year? It seems to me this is following out our general line in the past, which we know has been very profitable.

Mr. Voorhees. MR. S. S. VOORHEES.—I hesitate to say anything on the question of steel, as I have not been directly engaged in this line for some years, but it appears that this matter is fairly clear. We know, with certain compositions, what can be produced with proper heat treatment. As has been said, these are specifications for the raw material which will produce certain results under proper treatment. We do know that with certain compositions we can produce certain products if properly treated;

therefore, it would appear that chemical specifications are necessary to insure a uniform material for further treatment. **Mr. Voorhees.**

Mr. Devries. MR. DEVRIES.—As Mr. Howe has stated, we have to crawl or creep before we can walk; but if a tentative specification of the American Society for Testing Materials is going to mean anything, and it usually has meant something in the past, should it not at least provide for the selection of proper material? Trouble in getting steel up to the proper carbon or manganese content is rarely encountered, but a good deal of steel is offered for use which will never have the proper qualifications after being heat treated. If the artist is a man who has to produce from a raw product a finished article, he will have to have in this raw product the necessary elements to do so, and I wish to state that the chemistry does not begin to specify those necessary elements in the case of tool steel.

[The motion to accept the Specifications for Carbon Tool Steel as tentative was then carried.—ED.]

REPORT OF COMMITTEE A-2
ON
WROUGHT IRON.

During the past year, in addition to a number of meetings of the various sub-committees, there have been held two meetings of the committee. As a result of its work, the committee submits the following:

Proposed Tentative Specifications for Wrought-Iron Pipe.—As a result of a joint meeting with Sub-Committee IX of Committee A-1 and a representative committee from the American Society of Mechanical Engineers, Committee A-2 submits for the consideration and approval of the Society the appended proposed Tentative Specifications for Wrought-Iron Pipe.[1] These specifications include those sections of the present Standard Specifications for Welded Steel and Wrought-Iron Pipe (A 53–15) which apply to wrought-iron pipe as modified in accordance with the recommendations of the joint committee referred to above. The committee recommends that these specifications be published as tentative in accordance with the by-laws.

In this connection, the committee begs to report that it unanimously favors separate specifications for wrought-iron pipe and other wrought-iron material now included in specifications for similar steel products.[2]

Revision of Standard Specifications for Staybolt Iron.—As a result of joint meetings with a special committee of the Master Mechanics' Association with a view to having uniform specifications for staybolt iron adopted by the Society and the Master Mechanics' Association, the Standard Specifications for Staybolt Iron (A 39–14)[3] have been extensively revised and are appended to this report in their proposed revised form.[1] The committee recommends that they be published as tentative in accordance with the by-laws.

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[1] See pp. 568–572.—Ed.

[2] The Specifications here referred to are the following: For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52–15); for Welded Steel and Wrought-Iron Pipe (A 53–15); and for Iron and Steel Chain (A 56–15). See 1916 Book of A.S.T.M. Standards.—Ed.

[3] 1916 Book of A.S.T.M. Standards, p. 315.

At the time this report was written (May, 1917), the proposed Master Mechanics' specifications differed from the proposed revised specifications submitted by the committee in only two essential requirements, as follows: (1) The Master Mechanics' specifications permitted a range of from 47,000 to 52,000 lb. per sq. in. in tensile strength, with a secondary requirement limiting any one lot of iron to a permissible variation of only 3000 lb. per sq. in. in tensile strength, whereas it will be seen that the specifications appended limit the tensile strength to a flat range of from 48,000 to 52,000 lb. per sq. in. (2) The proposed Master Mechanics' specifications include requirements for manganese and phosphorus, whereas the specifications appended include only a manganese requirement.

Revision in Specifications for Refined Wrought-Iron Bars.—As a result of the difficulty experienced in obtaining refined wrought-iron bars in large sizes in accordance with the requirements for tensile strength of the Standard Specifications for Refined Wrought-Iron Bars (A 41–13),[2] the committee recommends the following revision in Section 4 of those specifications to meet this condition, with the understanding that the revision will be published for one year before being referred to letter ballot:

Change this section from its present form, namely,

> "4. For flat bars which have to be reduced in width, a deduction of 1000 lb. per sq. in. from the tensile strength specified in Sections 2 and 3 shall be made.",

to read:

> "4. For material over 4 sq. in. in sectional area, a reduction of 500 lb. per sq. in. from the tensile strength specified in Sections 2 and 3 will be permitted for each additional 2 sq. in., and a proportionate amount of reduction for fractional parts thereof; provided that the tensile strength shall not be more than 3000 lb. per sq. in. below the requirements specified in Section 2."

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[1] See pp. 564–567.—ED.

[2] 1916 Book of A.S.T.M. Standards, p. 322.

The permissible variations above proposed agree with the practice of the specifications of the U. S. Navy and the Pennsylvania Railroad Co.

Specifications for Wrought-Iron Blooms and Forgings.—During the year a Sub-Committee VI on Wrought-Iron Blooms and Forgings was appointed with Mr. H. E. Smith as chairman. As a result of a considerable amount of work and investigation on the part of this sub-committee, Committee A-2 recommends that the proposed Tentative Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars be printed as tentative in accordance with the by-laws.

The letter ballot of the committee on these four recommendations is as follows:

Recommendations.	Affirmative.	Negative.	Not Voting.
Proposed Tentative Specifications for Wrought-Iron Pipe....................	19	1	18
Proposed Tentative Specifications for Staybolt Iron........................	17	2	19
Proposed Tentative Revision of Standard Specifications for Refined Wrought-Iron Bars..	19	1	18
Proposed Tentative Specifications for Wrought-Iron Blooms and Forgings.....	17	1	20

This report has been referred to letter ballot of the committee, which consists of 38 members, of whom 25 have voted affirmatively, none negatively, and 13 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. V. HUNNINGS,
Chairman.

J. B. YOUNG,
Secretary.

EDITORIAL NOTE.

The tentative revision of the Standard Specifications for Refined Wrought-Iron Bars proposed in this report was accepted for publication in the Proceedings.

The three proposed tentative specifications referred to in the report were accepted for publication among the Tentative Standards of the Society, and appear on pages 564–575.

REPORT OF COMMITTEE A-3
ON
CAST IRON.

During the past year the activities of Committee A-3 have been directed to the following matters:

1. The constantly increasing sulfur content of gray-iron castings has brought about the demand for more latitude in this direction in the Standard Specifications for Gray-Iron Castings (A 48-05).[1] Sub-Committee VI on General Castings took the subject under advisement and reported in favor of increasing the maximum sulfur limit in light castings from 0.08 to 0.10 per cent. Committee A-3 therefore recommends that the proposed change be printed by the Society as tentative.

2. As stated in the report for 1916, the demand for specifications for soil pipe and fittings on the part of sanitary engineers and manufacturers has become very general. The difficulties encountered by the committee in the early stages of the work have been overcome, and proposed Tentative Specifications for Cast-Iron Soil Pipe and Fittings are appended to this report,[2] which the committee recommends be printed by the Society as tentative.

3. The change from general to specific standard specifications for malleable-iron castings, predicted as bound to come,[3] arrived sooner than expected. The revised specifications which went into effect in 1915 did not satisfy the demands for all classes of malleable castings. Sub-Committee V on Malleable Castings, in cooperation with a similar committee of the American Foundrymen's Association, drew up proposed Tentative Specifications for Railroad Malleable-Iron Castings, recommending that the present specifications be retained for the general run of work. The committee recommends that these specifications, which are appended hereto,[4] be printed by the Society as tentative.

The special requirements for conveyor-chain links will be taken up next by Sub-Committee V and proposed specifications presented in due time.

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[1] 1916 Book of A.S.T.M. Standards, p. 362.

[2] See pp. 576-581.—Ed.

[3] See Report of Committee A-3, *Proceedings*, Vol. XV, Part I, p. 123 (1915).

[4] See pp. 582-584.—Ed.

4. Sub-Committee III on Cylinders is at work in cooperation with a similar committee of the Master Car Builders' Association, on a revision of the present Standard Specifications for Cast-Iron Locomotive Cylinders (Serial Designation: A 45–14), which are also to be extended to embrace piston-valve bushings, piston-valve packing rings, piston-valve bull rings, cylinder bushings, piston packing rings, and piston head or bull rings.

5. Sub-Committee IV on Car Wheels is continuing the work of revising the existing Standard Specifications for Cast-Iron Car Wheels (Serial Designation: A 46–05).

6. A special sub-committee is at work on the standard screen scale for testing sieves recommended for adoption by the U. S. Bureau of Standards.

7. It is expected that the subject of molding sand will be taken up with Committee C–8 on Refractories, and a committee of the American Foundrymen's Association in the near future.

The letter ballot of the committee on its recommendations is as follows:

Recommendations.	Affirmative.	Negative.	Not Voting.
Proposed Tentative Revision of Standard Specifications for Gray-Iron Castings.	24	0	21
Proposed Tentative Specifications for Cast-Iron Soil Pipe and Fittings........	27	0	18
Proposed Tentative Specifications for Railroad Malleable-Iron Castings........	26	4	15

This report has been submitted to letter ballot of the committee, which consists of 45 members, of whom 23 have voted affirmatively, none negatively, and 22 have refrained from voting.

Respectfully submitted on behalf of the committee,

RICHARD MOLDENKE,
Chairman.

G. C. DAVIES,
Secretary.

EDITORIAL NOTE.

The tentative revision of the Standard Specifications for Gray-Iron Castings proposed in this report was accepted for publication in the Proceedings.

The two proposed tentative specifications referred to in the report were accepted for publication among the Tentative Standards of the Society, and appear on pages 576–584.

DISCUSSION.

Mr. Carson.

MR. HARRY Y. CARSON (*presented in written form and read by the author*).—When the relative merits of light-weight and extra heavy soil pipe and fittings are under discussion, there must be borne in mind, aside from the relative cost, not only the results obtained in the installation of the one against the other, with a proper regard to the sanitary effectiveness of the finished plumbing, but also the difficulties which confront the soil pipe manufacturer in the casting of pipe of a specified weight, demanding a wall thickness so thin as to make it most difficult to secure a uniform thickness of metal. Cast-iron soil pipe fittings deserve special consideration in this respect.

These two classes of soil pipe have a specified weight per foot, which results in an average wall thickness of $\frac{1}{8}$ in. in light-weight and $\frac{1}{4}$ in. in extra heavy pipe. Extra heavy pipe is illustrated in Fig. 1.

It is almost impossible in foundry practice to prevent a variation in individual pieces of as much as $\frac{1}{16}$ in.; and with the class of pipe known as "Standard," calling for a wall thickness of but $\frac{1}{8}$ in., when we consider this possible variation we are confronted with the very real danger illustrated in Fig. 2, which must exist in pipe having a wall thickness at any point of $\frac{1}{16}$ in. The factor of safety is too small.

With the best of foundry practice there is an ever-present variation in the thickness of the metal due to conditions obtaining in all foundry work which cannot be fully controlled. A slight slipping of the core knife in making the core will seriously affect the finished casting, as will also the slight bending of the pins joining the cope and drag sections of the pipe flask, thus affecting the parting or joining line.

If the conditions named did not exist in foundry practice, and an absolutely uniform wall thickness were possible, the manufacturer using a proper iron mixture could assure the purchaser of the furnishing of light-weight pipe which would satis-

Mr. Carson. factorily retain sewer gas; but there can be no such absolute assurance when actual foundry conditions are considered.

In the casting of extra heavy pipe with a wall thickness of $\frac{1}{4}$ in., while the same variation is both possible and permissible, the factor of safety is far greater, for the wall of the pipe should not, with the observance of high standards in foundry practice, be less than $\frac{3}{16}$ in., ample protection against leakage in the finished stack. See Fig. 3.

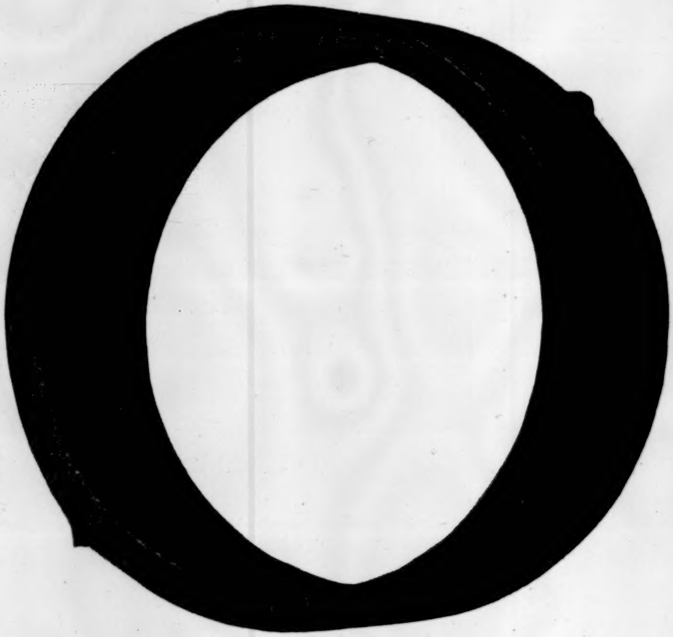

FIG. 1.—Extra Heavy Soil Pipe of Normal and Uniform $\frac{1}{4}$-in. Wall Thickness.

Both light and heavy-weight soil pipe are tested by some manufacturers to 50-lb. hydraulic pressure before being placed in stock. This results in the marketing of pipe which is watertight, and the test indicates that the pipe will withstand a pressure far in excess of that to which it will be subjected under working conditions. However, the customary water pressure test does not necessarily prove that the pipe will not leak gas,

Mr. Carson.

for it has been repeatedly demonstrated in the manufacture of gas pipe for pressure purposes that although a test under 300-lb. water pressure indicates no leaks, a pressure of less than 15 lb. with gas or air on the same line will show leakage. This is another argument in favor of extra heavy pipe with heavy walls, which in addition to withstanding the 50-lb. water test, has the wall thickness of at least $\frac{3}{16}$ in. as a guard against a very slight crack, due to rough handling or any number of other causes, which would not show up during the customary test of the soil pipe stack, but which in a pipe of thin wall might well

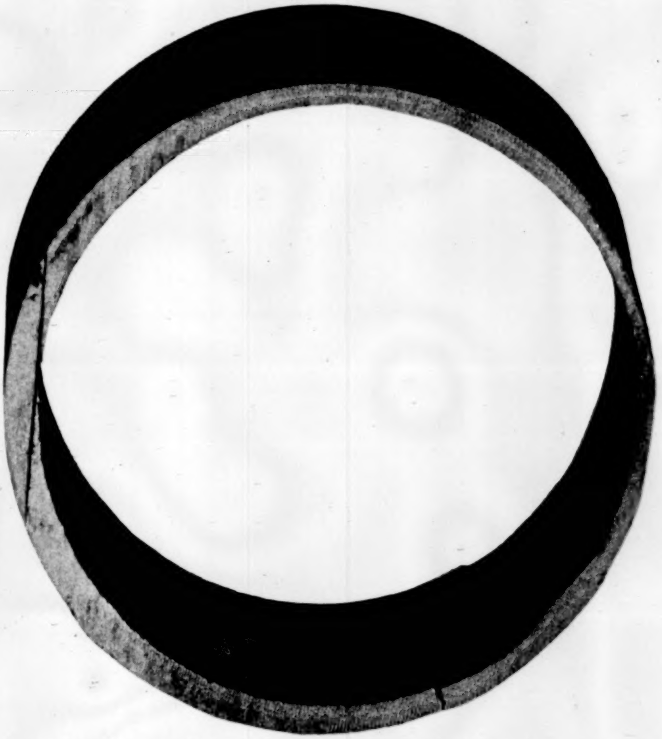

FIG. 2.—Light-Weight Soil Pipe, showing a $\frac{1}{16}$-in. Core Shift, leaving a Wall Thickness of only $\frac{1}{16}$ in. (Such material may fail by splitting.)

Mr. Carson. result in further cracking and the escape of sewer gas, after the building is finished and in use.

Thus far in this discussion little has been said of soil pipe fittings. For years, in fact since the New York City Plumbing Code of 1881, there have been specifications and requirements in all plumbing regulations governing the weight and wall thickness of soil pipe; but there have been no such specifications, until recently, which regulate soil pipe fittings.

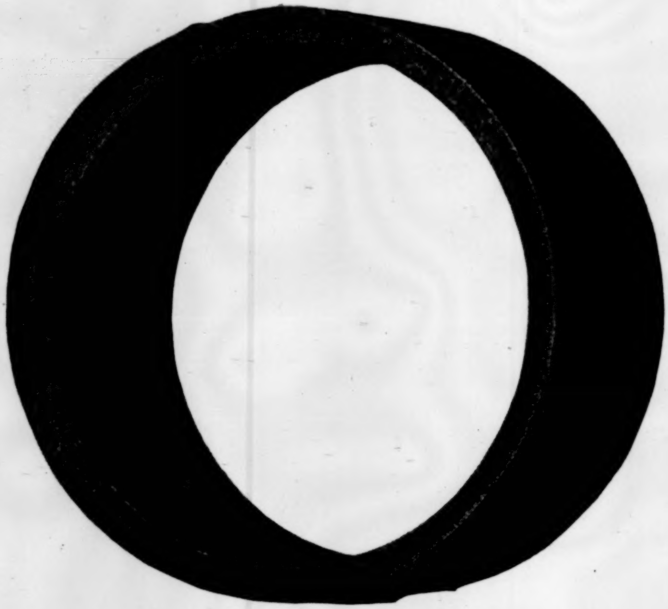

FIG. 3.—Extra Heavy Soil Pipe, showing a $\frac{1}{16}$-in. Core Shift, leaving $\frac{3}{16}$ in. of Metal on the Thinnest Portion of the Pipe.

That specifications for soil pipe fittings regulating not alone the weight of each fitting but its wall thickness, radii of bends, calking room, depth and thickness of hubs, and other essential dimensions have long been needed, is manifest by the efforts that have been made and the able work that has been accomplished in this direction during the past six years. A very desirable standard for soil pipe and fittings is now in existence and it is being adopted in the larger cities of the United States. **Mr. Carson.** This standard is known as the "Naco" specification for soil pipe and fittings.

In 1911 a committee made up of sanitary engineers, jobbers of plumbing supplies, plumbing inspectors and others familiar with trade conditions, were delegated to report on this subject to the American Society of Sanitary Engineering. A part of the investigation made by this committee consisted of a careful study of the existing wide variation in the weight and the dimensions of soil pipe fittings of different manufacture. A report on this subject was made by the Committee on Organization and Functions of Municipal Health Departments and was given in the Public Health Officials' Section of the American Public Health Association at Jacksonville, Fla., December 2, 1914. See Table I.

TABLE I.—VARIATIONS IN FITTINGS.[1]

STANDARD FITTINGS.

Size.	Minimum.	Maximum.	Difference.	Difference is .... per cent of Minimum.
4-in. $\frac{1}{4}$ Bend	9 lb. 0 oz.	11 lb. 1 oz.	2 lb. 1 oz.	22.9
4-in. $\frac{1}{8}$ Bend	4 " 12 "	11 " 0 "	6 " 4 "	131.8
4-in. $\frac{1}{16}$ Bend	4 " 8 "	9 " 4 "	4 " 12 "	105.5
4 by 4-in. San. Tee	13 " 0 "	18 " 0 "	5 " 0 "	38.5
4 by 4-in. Y	13 " 0 "	17 " 8 "	4 " 8 "	34.6
4-in. Long Sweep	13 " 4 "	20 " 0 "	6 " 12 "	50.9

EXTRA HEAVY FITTINGS.

Size.	Minimum.	Maximum.	Difference.	Difference is .... per cent of Minimum.
4-in. $\frac{1}{4}$ Bend	10 lb. 8 oz.	16 lb. 8 oz.	6 lb. 0 oz.	57.2
4-in. $\frac{1}{8}$ Bend	9 lb.	12 " 8 "	3 " 8 "	38.9
4-in. $\frac{1}{16}$ Bend	9 "	11 " 2 "	2 " 2 "	23.6
4 by 4-in. San. Tee	17 "	32 " 10 "	15 " 10 "	91.9
4 by 4-in. Y	18 "	25 " 4 "	7 " 4 "	40.3
4-in. Long Sweep	13 "	23 " 8 "	10 " 8 "	80.8

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[1] *American Journal of Public Health*, Vol. V, December, 1915, p. 1259.

Mr. Carson. A study made of plumbing codes from some two hundred of the leading cities in the United States revealed the fact that no attempt had as yet been made by Boards of Health or other proper authorities to regulate the dimensions and weight of soil pipe fittings. It is therefore only natural that the chaotic condition shown in Table I should exist. A chief reason for the lack of standardization has been that under the highly competitive conditions in the soil pipe business, this situation has resulted in the marketing of fittings of the *lightest possible weight.* Such fittings are necessarily fundamentally weak and of bad design; and a practice permitting this, while it demands pipe of $\frac{1}{4}$ in. in wall thickness, is extremely inconsistent. The stack is no safer and no more sanitary than the lightest and weakest fitting.

At the present writing it can be stated that all necessary progress has been made in creating the standard of weights and dimensions for extra heavy soil pipe fittings, so that now fittings can be furnished of such proportions as to correspond to the wall thickness and strength of extra heavy pipe; yet, there persists to-day a lax attitude in many of our cities with regard to the advantages to sanitation and economy that follow the adoption of this standard. On the other hand, some of the larger and more progressive communities such as Cleveland, O., Portland, Ore., and the State of Wisconsin have not been slow to see those very real advantages which do come. Consequently these localities have passed laws that are now in effect and require that the extra heavy fittings shall conform to this standardized specification.

The layman, unfamiliar with the various items of cost which enter into the final analysis of a house drainage job, might at first favor the general use of light-weight pipe on the ground that its price as listed in the manufacturers' catalog is less than that for heavy pipe. This argument is offset, however, by the reduction in the cost of heavy pipe when it becomes the single standard of a given community. Every business man knows that the cost of a commodity like pipe depends upon other factors than the mere cost of manufacturing it. For instance, when the jobber must carry both light-weight pipe and extra heavy pipe in stock to supply his trade, he is forced to have

Mr. Carson.

more money invested in store room and hired help for the purpose of carrying double quantities of material on hand. When the kind and quality of soil pipe fittings are multiplied by two or, as is often the case, three different standards, the jobber is put to much trouble and expense in keeping his trade well supplied with their needs. This expense necessarily is added to the plumber's bill.

Soil pipe stacks are subject to very great strain, despite the fact that the interior pressure except under test or complete stoppage of the plumbing is practically nil. The strain arises from the settlement of the building and from great variation in temperature which is due to the flow of alternate hot and cold waste matter through the waste lines, causing excessive contraction and expansion. In light-weight soil pipe stacks these strains are liable to split the hubs or crack the pipe—not with sufficient frequency, perhaps, to indicate through the leaking of waste matter and consequent wetting of the ceilings and walls that such a condition exists, but sufficient to permit the escape of sewer gas.

Modern plumbing regulations insist upon proper venting of plumbing installations in order that gases and odors of every description may be discharged outside the building, and the object of such plumbing regulations is set at naught if pipe is installed of a grade so light that the stack may not withstand the strains to which it is subjected, particularly so when one considers the impossibility of detection due to the concealment of the stack. Light-weight pipe, while withstanding the usual water test at the foundry, may still have the uneven wall thickness alluded to in the early part of this discussion, and when one considers that soil pipe stacks are installed between the walls of buildings, between partitions covered with lathing and plaster, and so sealed as to preclude future inspection, the necessity for installing a grade of pipe that is sure to guard against leakage of gases or sewage is evident.

Therefore, it may be said in conclusion that from an economical standpoint the frequently claimed advantage of installing light-weight pipe is extremely doubtful and most certainly from the point of view of the property owner or the occupant of the house, there can be no question as to the

Mr. Carson. advantage of using the extra heavy pipe and standardized extra heavy fittings of known weight and dimensions which, on account of the proper wall thickness, is an absolute safeguard of health and a permanent installation.

To summarize these points, we have:

First, light-weight pipe suffers because of thin walls; the hubs are cracked by rough handling to the job; the pipe is split in cutting; and light-weight fittings are even more liable to fail than light-weight pipe.

Second, more leaks occur in testing the light-weight pipe on the job and this causes the added expense of removing and replacing material.

Third, when the plumber may be able to get a stack of light-weight material of sufficient tightness to pass a sanitary inspection, small unobserved cracks may later develop and the house owner be compelled to remove the piping at considerable cost and annoyance to himself.

Fourth, due to the normal settlement of buildings and the variation in the temperature of the waste water, strains are set up in soil stacks which are liable to break the hubs of light-weight material. Cast-iron soil pipe and fittings in which the minimum wall thickness is established as $\frac{1}{4}$ in. and with suitable hubs, spigots, calking room, radii of bends, etc., constitute the only safe and economical type of house drainage installation.

REPORT OF COMMITTEE A-5

ON

CORROSION OF IRON AND STEEL.

Committee A-5 has completed the erection of the test racks described in its report for 1915[1] and all the sheets of metal are now exposed.

Those at Annapolis, Md., and Pittsburgh, Pa., were placed on the racks during October and December of 1916 and those at Fort Sheridan, Ill., in April of this year.

The Inspection Committee, with a number of members of Committee A-5, inspected the sheets at Pittsburgh and Annapolis last April and made notes on their condition. Certain peculiarities were observed indicating differences between the conditions of the various sheets at both locations, but it was decided that no specific report could be made at present. All of the sheets in series B have been analyzed, but on account of certain inconsistencies in the results, some of the determinations should be checked before they are published. None of the figures will be included in the report this year.

Sub-Committee II on Preservative Metallic Coatings for Metals, which was created last year, has concluded its study of the determination of zinc in galvanized coatings. It presents a report on a comparison of the basic-lead-acetate and the hydrochloric acid - antimony chloride methods of treating galvanized sheets and wire, which it is believed is a valuable contribution to the testing of these products. The report is appended hereto.

This report has been submitted to letter ballot of the committee, which consists of 41 members, of whom 34 have voted affirmatively, 1 negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. S. VOORHEES,
Chairman.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 130 (1915).

APPENDIX.

REPORT OF SUB-COMMITTEE II OF COMMITTEE A-5

ON

PRESERVATIVE METALLIC COATINGS FOR METALS.

Sub-Committee II was formed at the close of the preceding year for the study of metallic coatings, as was so stated in the annual report of Committee A-5 for 1916. The first subject to be taken up was the relative merits of the methods in common use for determining the weight of coating of galvanized materials. The following report by Mr. H. S. Rawdon summarizes the results obtained up to date:

The methods in current commercial use for determining the amount of zinc coating on galvanized materials are (1) the "Preece" test (immersion in neutral copper-sulfate solution), (2) the basic-lead-acetate method, and (3) stripping in concentrated hydrochloric acid containing antimony chloride. Committee A-5 has already expressed an opinion condemning the use of the copper-sulfate method[1] and it was considered unnecessary to do further work along this line. The sub-committee decided to limit its first work to a study of the relative merits of the second and third methods noted above as applied to sheets and wires prepared by the "hot-dipping" process.

A comprehensive list of questions requesting information concerning the testing and sampling of metallic coatings for metals was submitted to some 75 parties, including manufacturers, consumers, and testing laboratories. It was hoped that the information gained would be helpful in orienting the work of the sub-committee. The replies, however, contained so many individual opinions that no general summary was possible, yet the following facts gleaned from these replies may be pointed out:

1. The Preece test is still in very prevalent use in spite of

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XI, p. 100 (1911).

its general condemnation; particularly is it recommended for inspection purposes, on account of its ease of manipulation, no necessity for use of a balance, and consistent results "if properly carried out." This test appears to be used entirely for the inspection of wire. Many of the replies stated that the thickness of coating for such material is expressed as the number of immersions required by the Preece test for stripping off the coating.

2. There is a considerable diversity of physical tests, the tendency being that only in case the sheet material is to be fabricated, should physical tests be specified, and that such tests should bear some relation to the use to which that particular gage is to be put.

3. No uniformity whatever in the method of sampling sheet material prevails. Wires are universally sampled at the end of the reel or coil.

4. The thickness of coating on sheets is very generally expressed in ounces per square foot; that is, 1 sq. ft. includes both surfaces of the sheet.

5. The thickness of wires (by users and inspectors in general) is quite generally expressed in terms of the number of immersions in the Preece test. Other methods used (or suggested) are ounces per ton, ounces per unit area, and ounces per unit length.

SCOPE OF INVESTIGATION.

Material.—The material used in the work was of two kinds, sheets and wires, and was prepared by three members of the sub-committee especially for this investigation. The sheets were furnished by the American Sheet and Tin Plate Co. and the American Rolling Mill Co. These samples are designated "S" and "R," respectively. They vary in gage from Nos. 16 to 26, inclusive, as shown below.

16-gage	S	samples	10	sheets
16 "	R	"	14	"
20 "	R	"	2	"
22 "	R	"	4	"
24 "	R	"	4	"
26 "	R	"	6	"
26 "	S	"	10	"
Total sheets sampled			**50**	

The wire samples, No. 9 gage, were furnished by the American Steel and Wire Co. and represented "2-minute wiped," "3-minute wiped," "4-minute wiped," and "unwiped" wire; each reel being sampled from the front, center, and back end; the total number of samples being 12.

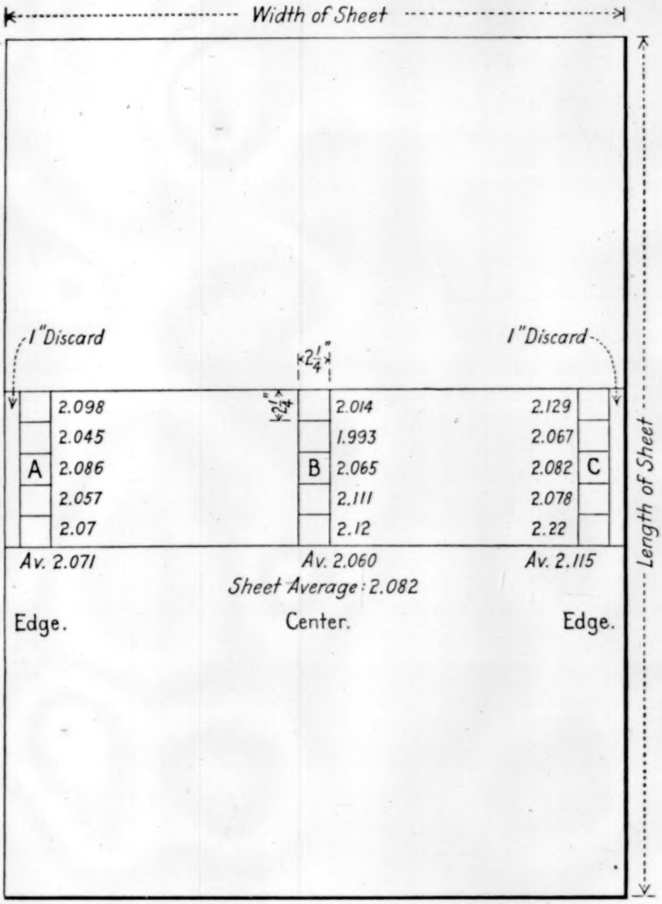
Cooperating Laboratories.—The laboratories cooperating in the work were designated by Nos. 1, 2, 3, 4, 5, 6, 7 and 8. Each laboratory received samples of all the wires; this was not possible, however, with the sheet samples.

Sampling.—The sheets were sampled by the two companies furnishing this material according to the plan shown in Fig. 1, this plan having been approved by both companies. (See "Comparison of Methods of Sampling," and Fig. 14.) A strip 13 or 14 in. wide was cut from the center of each sheet parallel to the short dimension. A portion 1 in. wide was cut from each end of this strip, and these ends were discarded. A series of $2\frac{1}{4}$-in. squares was then cut from each end of this strip and from the central portion as shown in Fig. 1. By using samples $2\frac{1}{4}$ in. square, the loss of weight determined in grams is numerically equivalent to the weight of the coating per square foot expressed in ounces. These were apportioned to the various cooperating laboratories by the chairman, no information other than an identification number being given.

Samples of each bundle of wire were cut according to the scheme given under the hydrochloric acid - antimony chloride method of testing, which follows later. The samples were cut to a 9-in. length rather than $10\frac{15}{16}$ in. required. This introduces no appreciable error and the result, that is, the loss of weight in grams, is easily convertible into ounces of coating per square foot, by using the factor 1.215 (ratio of the two lengths).

In order to cut the wires accurately to length, some form of press was necessary. The samples were firmly clamped in a wooden press, one side of which was grooved to hold the wire, the ends projecting through a perforated metal plate at each end of the press. The wire was sawed approximately to length and then filed until flush with the metal plate.

Methods.—The two methods studied were the basic-lead-acetate and the hydrochloric acid - antimony chloride methods. The Preece test had previously been condemned by Commit-


Width of Sheet
Length of Sheet
1" Discard
1" Discard
$2\frac{1}{4}$"
$2\frac{1}{4}$"
A
B
C
2.098
2.045
2.086
2.057
2.07
2.014
1.993
2.065
2.111
2.12
2.129
2.067
2.082
2.078
2.22
Av. 2.071
Av. 2.060
Av. 2.115
Sheet Average: 2.082
Edge.
Center.
Edge.

Note: For Commercial Testing, Squares A, B and C may be Used.
Numerals Represent Weight of Zinc Coating in ounces per square foot.

FIG. 1.—Method of Sampling Sheets and Reporting Results.

tee A-5 and additional work upon this method was considered unnecessary.

The basic-lead-acetate method as described by Patrick and Walker[1] consists in the immersions of the sample which has been previously cleaned, dried, and weighed in a solution of lead acetate of known concentration; the zinc passes into solution and a layer of spongy lead which can be easily removed from the surface of the sample, replaces it. A series of several 4-minute immersions with alternate scrubbing to remove the lead is practically always necessary. The difference in weight between the original, or coated, sample and the same after stripping represents the weight of zinc coating.

The hydrochloric acid - antimony chloride method as described by Aupperle[2] consists of immersions of the samples tested in concentrated hydrochloric acid (sp. gr., 1.20) to which has been added a small amount of a solution of antimony chloride (5 cc. of a solution prepared by dissolving 20 g. of antimony trioxide in 1 liter of concentrated hydrochloric acid, sp. gr. 1.20, are added to each 100 cc. of acid used). Immersions of 1-minute duration are considered ample. The samples are cut to size so that the loss of weight in grams is numerically equal to the weight of coating in ounces per square foot. Wires of No. 9 gage, the size used, should be cut in lengths of $10\frac{15}{16}$ in. If lengths other than this are used, the result should be multiplied by the proper factor, that is, the ratio of the two lengths, in order that the result will be equal numerically to the number of ounces of coating per square foot of surface.

RESULTS OF TESTS.

Sheets.—The results obtained by the various cooperating laboratories are given in Table I. Fig. 1 illustrates the method of sampling and the recording of the results. All of the results for sheets are expressed as ounces per square foot of running surface, that is, 1 sq. ft. includes both sides; for wires, results are expressed as ounces per square foot of actual surface. For comparable results the results for sheets should be divided by 2. Figs. 2–10, inclusive, show the results graphically.

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[1] *Journal of Industrial and Engineering Chemistry*, Vol. 3, p. 239 (1911).

[2] "The Determination of Spelter Coating on Sheets and Wire," *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 119 (1915).

The term "mill value" used in Table I and the discussion referring to sheets, means the weight of coating determined at the mill, by weighing the sheet before and after galvanizing.

Wires.—Each of the cooperating laboratories received samples of each of the wires and in Table II the results are grouped under the proper laboratory number. Figs. 11, 12 and 13 show these results graphically. The tendency of certain laboratories to run higher or lower than the general average is well illustrated. Table III gives a summary of the results.

TABLE I.—RESULTS OF TESTS ON SHEETS.

Sample No.	Gage No.	Actual Weight of Zinc Coating,[a] oz. per sq. ft. of running surface.	Method of Testing.	Weight of Zinc Coating by Test, oz. per sq. ft. of running surface.				Deviation of Average Weight of Zinc Coating from Actual Weight, per cent.
				Edge.	Center.	Edge.	Average of Sheet.	
S-5	16	1.88	Basic-lead-acetate	1.496[b]	1.714	1.851		
				.....	.....	1.730		
				1.975	1.768	1.726		
				1.914	1.734	1.720		
				1.915	1.801	1.891		
Aver....	......	....	....	1.935	1.754	1.783	1.787	−4.95
S-6	16	1.85	Hydrochloric acid-antimony chloride	.....	1.690	2.019		
				1.845	1.699	2.130		
				1.860	1.801	3.585[b]		
				1.719	.....	1.910		
				1.951	1.814	1.866		
Aver....	......	....	....	1.844	1.751	1.981	1.859	+0.485
S-7	16	1.88	Basic-lead-acetate	2.176	1.788	.....		
				2.008	1.803	1.736		
				.....	1.790	1.925		
				1.086[b]	1.911	1.922		
				2.035	1.977	1.932		
Aver....	......	....	....	2.073	1.854	1.879	1.935	+2.92
S-13	16	1.93	Basic-lead-acetate	1.868	1.775	1.683		
				1.960	1.942	1.741		
				1.999	1.933	.....		
				1.988	2.029	1.544		
				.....	1.780	1.613		
Aver....	......	....	....	1.954	1.892	1.645	1.830	−5.17
S-14	16	1.85	Hydrochloric acid-antimony chloride	1.824	1.843	.....		
				1.703	.....	1.810		
				1.835	1.879	1.823		
				1.800	1.779	1.863		
				1.848	1.708	1.883		
Aver....	......	....	....	1.802	1.802	1.845	1.816	−1.84
S-16	16	1.85	Hydrochloric acid-antimony chloride	.....	1.640	1.842		
				1.801	1.751	1.856		
				1.756	1.792	1.793		
				1.653	.....	1.780		
				1.778	1.695	1.761		
Aver....	......	....	....	1.747	1.719	1.806	1.757	−4.95

[a] Mill value—difference in weight between black and coated sheets.
[b] Not included in average.
NOTE.—Results should be divided by 2 to be comparable with those of Tables II and III.

TABLE I.—RESULTS OF TESTS ON SHEETS (*Continued*).

Sample No.	Gage No.	Actual Weight of Zinc Coating,[a] oz. per sq. ft. of running surface.	Method of Testing.	Weight of Zinc Coating by Test, oz. per sq. ft. of running surface.				Deviation of Average Weight of Zinc Coating from Actual Weight, per cent.
				Edge.	Center.	Edge.	Average of Sheet.	
S-17	16	2.05	Basic-lead-acetate	1.930	1.999	.....		
				1.953	2.131	2.053		
				.....	2.050	2.161		
				1.981	1.977	1.943		
				1.980	1.832	1.979		
Aver....				1.961	1.998	2.034	1.997	−2.58
S-18	16	2.08	Hydrochloric acid-antimony chloride	1.886	2.005	2.158		
				1.820	2.126	2.209		
				1.922	.....	.....		
				1.824	1.985	2.432		
				1.926	2.050	2.121		
Aver....				1.875	2.041	2.230	2.049	−1.49
S-19	16	2.15	Basic-lead-acetate	2.193	2.199	2.163		
				2 280	.....	2.210		
				2.103	2.177	2.124		
				2.240	2.126	2.322		
				2.274	2.085	1.997		
Aver....				2.218	2.122	2.163	2.167	+0.79
S-20	16	1.85	Hydrochloric acid-antimony chloride	.....	1.950	1.815		
				2.138	1.899	1.859		
				1.927	2.017	1.940		
				1.787	.....	1.840		
				1.857	1.965	1.778		
Aver....				1.927	1.958	1.846	1.910	+3.24
S-1	26	1.73	Basic-lead-acetate	1.480	.....	2.049		
				1.469	1.509	.....		
				1.501	1.568	1.747		
				1.676	1.593	1.615		
				1.586	1.671	1.553		
Aver....				1.542	1.585	1.741	1.623	−6.19
S-2	26	1.33	Hydrochloric acid-antimony chloride	1.470	.....	1.535		
				1.520	1.290	1.516		
				1.541	1.300	1.505		
				1.501	1.280	.....		
				1.504	1.293	1.492		
Aver....				1.507	1.291	1.512	1.437	+8.04
S-3	26	1.85	Basic-lead-acetate	1.782	1.491	2.100		
				1.786	1.540	2.023		
				1.780	.....	2.025		
				1.811	1.611	2.070		
				1.763	1.615	2.046		
Aver....				1.784	1.564	2.053	1.800	−2.7
S-4	26	1.80	Hydrochloric acid-antimony chloride	1.782	1.876	1.061[b]		
				.....	1.830	.....		
				1.818	1.919	2.230		
				1.740	1.931	2.325		
				2.189	1.817	2.265		
Aver....				1.882	1.874	2.273	2.010	+11.66

[a] Mill value—difference in weight between black and coated sheets.
[b] Not included in average.
NOTE.—Results should be divided by 2 to be comparable with those of Tables II and III.

TABLE I.—RESULTS OF TESTS ON SHEETS (*Continued*).

Sample No.	Gage No.	Actual Weight of Zinc Coating,[a] oz. per sq. ft. of running surface.	Method of Testing.	Weight of Zinc Coating by Test, oz. per sq. ft. of running surface.				Deviation of Average Weight of Zinc Coating from Actual Weight, per cent.
				Edge.	Center.	Edge.	Average of Sheet.	
S-5	26	1.80	Basic-lead-acetate	1.790	.....	.....		
				1.722	1.606	2.339		
				1.719	1.589	2.325		
				1.669	1.511	2.216		
				1.630	1.491	2.261		
Aver....				1.706	1.549	2.285	1.847	+2.61
S-6	26	1.33	Hydrochloric acid-antimony chloride	1.494	1.247	1.549		
				1.380	1.228	1.604		
				1.400	.....	.....		
				1.414	1.235	1.469		
				1.428	1.185	1.582		
Aver....				1.423	1.224	1.551	1.400	+5.26
S-7	26	1.23	Basic-lead-acetate	1.345	1.133	1.287		
				1.316	1.171	1.281		
				1.350	1.133	1.320		
				1.341	1.103	1.290		
				1.430	.....	1.409		
Aver....				1.356	1.135	1.317	1.270	+3.25
S-8	26	1.85	Hydrochloric acid-antimony chloride	2.311	1.487	1.823		
				2.262	1.542	1.890		
				2.210	1.536	1.917		
				.....	.....	1.750		
				2.221	1.581	1.835		
Aver....				2.251	1.537	1.843	1.877	+1.46
S-9	26	1.90	Basic-lead-acetate	1.762	1.597	2.510		
				.....	.....	2.101		
				1.785	1.597	2.194		
				2.113	1.660	1.990		
				1.786	1.600	2.029		
Aver....				1.862	1.614	2.165	1.880	−1.05
S-10	26	1.35	Hydrochloric acid-antimony chloride	1.404	1.277	1.460		
				1.300	1.274	1.449		
				1.330	.....	1.385		
				1.391	1.250	1.501		
				1.456	1.289	1.525		
Aver....				1.376	1.273	1.464	1.371	+1.55
R-1	26	1.44	Basic-lead-acetate	.....	.....	.....		
				1.483	1.358	1.559		
				1.288	1.402	1.568		
				1.162	1.446	1.577		
Aver....				1.311	1.402	1.568	1.427	−0.905
R-2	24	1.54	Hydrochloric acid-antimony chloride	1.951	1.832	1.646		
				.....	.....	.....		
				1.828	1.877	1.676		
				1.719	1.836	1.669		
				2.000	1.780	1.820		
Aver....				1.875	1.831	1.703	1.803	+16.9

[a] Mill value—difference in weight between black and coated sheets.

NOTE.—Results should be divided by 2 to be comparable with those of Tables II and III.

TABLE I.—RESULTS OF TESTS ON SHEETS (*Continued*).

Sample No.	Gage No.	Actual Weight of Zinc Coating,[a] oz. per sq. ft. of running surface.	Method of Testing.	Weight of Zinc Coating by Test, oz. per sq. ft. of running surface.				Deviation of Average Weight of Zinc Coating from Actual Weight, per cent.
				Edge.	Center.	Edge.	Average of Sheet.	
R-3	16	1.93	Basic-lead-acetate	1.886	1.843	1.968		
				.....	.....	.....		
				2.068	1.866	1.953		
				1.949	1.870	2.034		
Aver....	......	....	....	1.9676	1.8596	1.985	1.937	+0.36
R-4	16	2.13	Hydrochloric acid-antimony chloride	2.006	1.913	1.968		
				.....	.....	.....		
				2.016	1.916	2.082		
				2.021	1.964	2.149		
				1.980	1.850	2.300		
Aver....	......	....	....	2.0057	1.9107	2.1247	2.014	−5.45
R-5	20	1.41	Basic-lead-acetate	1.435	1.435	1.493		
				1.448	1.411	1.447		
				.....	.....	.....		
				1.497	1.479	1.553		
Aver....	......	....	....	1.460	1.4416	1.4976	1.466	+3.97
R-6	16	2.27	Hydrochloric acid-antimony chloride	2.098	2.014	2.129		
				2.045	1.993	2.067		
				2.086	2.065	2.082		
				2.057	2.111	2.078		
				2.070	2.120	2.220		
Aver....	......	....	....	2.071	2.0606	2.115	2.082	−8.3
R-7	26	1.36	Basic-lead-acetate	1.222	1.300	1.746		
				1.231	1.291	1.718		
				1.162	1.331	1.682		
				1.172	1.372	1.737		
Aver....	......	....	....	1.1967	1.3235	1.7207	1.414	+3.97
R-8	16	2.04	Hydrochloric acid-antimony chloride	2.047	1.903	1.938		
				2.112	2.018	1.879		
				2.204	2.198	1.992		
				2.205	2.354	1.922		
				2.180	2.240	2.030		
Aver....	......	....	....	2.1496	2.1426	1.952	2.081	+2.01
R-9	16	1.90	Basic-lead-acetate	1.725	1.644	1.899		
				1.704	1.580	1.895		
				.....	.....	.....		
				1.733	1.634	1.860		
Aver....	......	....	....	1.7206	1.619	1.8846	1.742	−8.33
R-10	16	1.95	Hydrochloric acid-antimony chloride	1.857	1.684	1.732		
				1.845	1.692	1.706		
				1.874	1.778	1.802		
				1.872	1.715	1.790		
				1.900	1.730	1.820		
Aver....	......	....	....	1.8696	1.7198	1.770	1.786	−8.4

[a] Mill value—difference in weight between black and coated sheets.

NOTE.—Results should be divided by 2 to be comparable with those of Tables II and III.

TABLE I.—RESULTS OF TESTS ON SHEETS (*Continued*).

Sample No.	Gage No.	Actual Weight of Zinc Coating,[a] oz. per sq. ft. of running surface.	Method of Testing.	Weight of Zinc Coating by Test, oz. per sq. ft. of running surface.				Deviation of Average Weight of Zinc Coating from Actual Weight, per cent.
				Edge.	Center.	Edge.	Average of Sheet.	
R-11	16	1.92	Basic-lead-acetate	2.002 1.921 1.826 1.819	1.865 1.796 2.423 1.735	1.976 1.878 1.378 1.783		
Aver....				1.892	1.9547	1.7537	1.867	−2.76
R-12	16	1.95	Hydrochloric acid-antimony chloride	2.288 2.158 2.126 2.239 2.180	2.203 2.176 2.094 2.202 2.250	2.184 2.153 2.076 2.201 2.070		
Aver....				2.198	2.185	2.1368	2.173	+11.4
R-13	16	1.91	Basic-lead-acetate	1.794 1.793 ..... 1.680	1.829 1.845 ..... 1.775	1.742 1.829 ..... 1.920		
Aver....				1.7556	1.816	1.830	1.801	−5.71
R-14	20	1.28	Hydrochloric acid-antimony chloride	1.273 1.341 1.301 1.308 1.300	1.327 1.322 1.269 1.269 1.290	1.367 1.454 1.363 1.389 1.380		
Aver....				1.3046	1.295	1.3906	1.330	+3.9
R-15	16	2.02	Basic-lead-acetate	..... 2.208 2.230 2.116	..... 1.948 1.982 1.918	..... 2.074 2.039 2.115		
Aver....				2.1846	1.949	2.076	2.070	+2.45
R-16	16	2.04	Hydrochloric acid-antimony chloride	1.843 2.016 2.108 1.864 1.800	2.058 2.029 2.230 2.130 2.000	1.997 2.059 2.069 2.032 2.030		
Aver....				1.926	2.089	2.037	2.018	−1.06
R-17	22	1.45	Basic-lead-actate	1.605 1.556 1.568 1.653	1.584 1.562 1.592 1.611	1.406 1.447 1.441 1.409		
Aver....				1.5955	1.587	1.4257	1.536	+5.93
R-18	16	2.04	Hydrochloric acid-antimony chloride	..... 2.160 2.253 2.053 1.970	..... 2.257 2.037 2.138 2.214	..... 2.224 2.400 2.098 2.270		
Aver....				2.109	2.1615	2.248	2.173	+6.53

[a] Mill value—difference in weight between black and coated sheets.

NOTE.—Results should be divided by 2 to be comparable with those of Tables II and III.

TABLE I.—RESULTS OF TESTS ON SHEETS (*Continued*).

Sample No.	Gage No.	Actual Weight of Zinc Coating,[a] oz. per sq. ft. of running surface.	Method of Testing.	Weight of Zinc Coating by Test, oz. per sq. ft. of running surface.				Deviation of Average Weight of Zinc Coating from Actual Weight, per cent.
				Edge.	Center.	Edge.	Average of Sheet.	
R-19	16	2.00	Basic-lead-acetate	2.031	2.250	1.896		
				2.040	1.993	1.826		
				1.973	2.138	1.910		
				2.004	2.048	1.800		
Aver....				2.012	2.107	1.858	1.992	−0.4
R-20	16	1.96	Hydrochloric acid-antimony chloride	.....	.....	.....		
				1.951	1.928	1.879		
				2.024	1.906	1.924		
				1.945	1.908	1.817		
				1.930	1.900	1.900		
Aver....				1.9625	1.9105	1.880	1.918	−2.2
R-21	22	1.27	Basic-lead-acetate	1.267	1.250	1.344		
				1.254	1.283	1.365		
				1.319	1.289	1.347		
				1.335	1.250	1.388		
Aver....				1.2937	1.268	1.361	1.308	+2.99
R-22	24	1.27	Hydrochloric acid-antimony chloride	1.508	1.424	1.315		
				1.499	1.381	1.318		
				.....	.....	.....		
				1.404	1.374	1.312		
				1.430	1.410	1.300		
Aver....				1.406	1.397	1.311	1.390	+8.76
R-23	22	1.24	Basic-lead-acetate	1.361	1.268	1.221		
				1.370	1.289	1.265		
				.....	.....	.....		
				1.361	1.226	1.337		
Aver....				1.364	1.261	1.274	1.300	+4.84
R-24	22	1.28	Hydrochloric acid-antimony chloride	1.201	1.228	1.213		
				1.239	1.262	1.243		
				1.224	1.227	1.214		
				1.195	1.197	1.241		
				1.160	1.230	1.190		
Aver....				1.2038	1.2288	1.220	1.218	−4.84
R-25	26	1.40	Basic-lead-acetate	1.326	1.338	1.325		
				.....	.....	.....		
				1.324	1.317	1.340		
				1.327	1.303	1.283		
Average.				1.3256	1.3193	1.316	1.320	−5.7
R-26	26	1.375	Hydrochloric acid-antimony chloride	1.447	1.499	1.605		
				1.390	2.164[b]	1.882		
				1.369	1.478	1.556		
				1.339	1.530	1.601		
				1.340	1.540	1.620		
Aver....				1.377	1.512	1.632	1.514	+1.01

[a] Mill value—difference in weight between black and coated sheets.
[b] Not included in average.
NOTE.—Results should be divided by 2 to be comparable with those of Tables II and III.

TABLE I.—RESULTS OF TESTS ON SHEETS (*Continued*).

Sample No.	Gage No.	Actual Weight of Zinc Coating,[a] oz. per sq. ft. of running surface.	Method of Testing.	Weight of Zinc Coating by Test, oz. per sq. ft. of running surface.				Deviation of Average Weight of Zinc Coating from Actual Weight, per cent.
				Edge.	Center.	Edge.	Average of Sheet.	
R-27	26	1.385	Basic-lead-acetate	1.441	1.465	1.495		
				1.414	1.517	1.531		
				.....	.....	.....		
				1.354	1.498	1.480		
Aver....	......	....	....	1.403	1.493	1.502	1.466	+5.85
R-28	26	1.345	Hydrochloric acid-antimony chloride	1.233	1.276	1.356		
				1.273	1.255	1.348		
				1.257	1.279	1.393		
				1.300	1.380	1.456		
				1.290	1.420	1.470		
Aver....	......	....	....	1.2706	1.322	1.405	1.333	−0.89
R-29	24	1.24	Basic-lead-acetate	1.315	1.400	1.425		
				1.299	1.410	1.475		
				.....	.....	.....		
				1.260	1.359	1.456		
Aver....	......	....	....	1.291	1.390	1.452	1.378	+1.11
R-30	24	1.27	Hydrochloric acid-antimony chloride	1.298	1.281	1.286		
				1.322	1.280	1.299		
				1.341	1.266	1.281		
				1.360	1.274	1.308		
				1.380	1.270	1.240		
Aver....	......	....	....	1.340	1.274	1.283	1.292	+1.57

[a] Mill value—difference in weight between black and coated sheets.

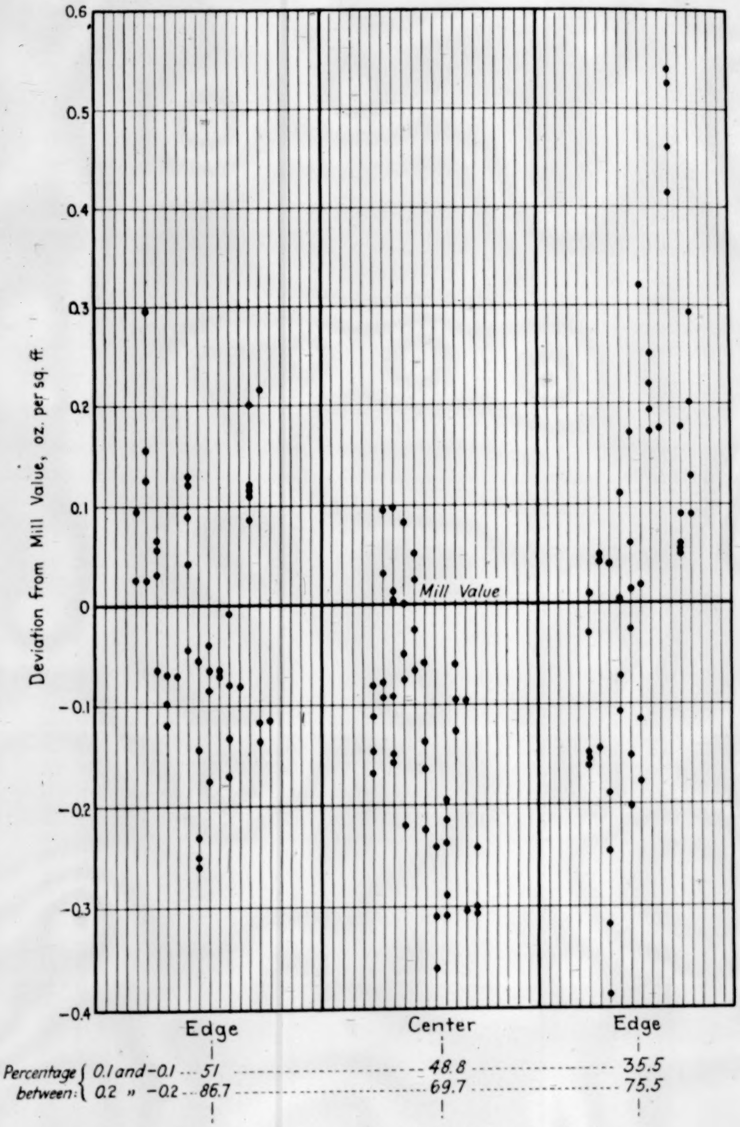
NOTE.—Results should be divided by 2 to be comparable with those of Tables II and III.

TABLE II.—RESULTS OF TESTS ON WIRE.

Sample No.	Description.	Weight of Zinc Coating, oz. per sq. ft. of Actual Surface.																		Deviation of Hydrochloric Acid-Antimony Chloride Method from Basic-Lead-Acetate Method, per cent.
		Basic-Lead-Acetate Method.									Hydrochloric Acid-Antimony Chloride Method.									
		Laboratory No.									Laboratory No.									
		1	2	3	4	5	6	7	8	Average.	1	2	3	4	5	6	7	8	Average.	
	2-MIN. WIPED WIRE.																			
1	Front end of reel	0.413 0.401	0.378 0.383	0.387 0.361	0.414	0.392	0.396 0.396	0.419	0.418 0.401	0.396	0.449 0.432	0.414	0.407	0.432 0.424	0.419 0.399	0.439	0.457 0.429	0.424	0.427	7.80
2	Center of reel..	0.407 0.401	0.385	0.370 0.357	0.405 0.399	0.391	0.396	0.394 0.393	0.397	0.392	0.426 0.407	0.403 0.397	0.404	0.416	0.407 0.405	0.423 0.429	0.437	0.411 0.409	0.413	5.35
3	Rear end of reel	0.413 0.444	0.417	0.405 0.373	0.439	0.418	0.406	0.419	0.420	0.420	0.450 0.480	0.421 0.426	0.443	0.457 0.453	0.426 0.439	0.423 0.476	0.454 0.462	0.435	0.447	6.40
	3-MIN. WIPED WIRE.																			
4	Front end of reel	0.589 0.589	0.583	0.559	0.590 0.603	0.585	0.585	0.594 0.567	0.579	0.584	0.566 0.589	0.571 0.571	0.619 0.597	0.598	0.597 0.589	0.634 0.585	0.587	0.571 0.627	0.596	2.30
5	Center of reel ..	0.577 0.572	0.600 0.594	0.581	0.592	0.574	0.577	0.555	0.580 0.569	0.563	0.577 0.596	0.591	0.598 0.594	0.597 0.600	0.588 0.574	0.594 0.596	0.607 0.604	0.580	0.596	5.86
6	Rear end of reel	0.554 0.541	0.547	0.529	0.549 0.549	0.552	0.547	0.550 0.555	0.546	0.547	0.554 0.559	0.551 0.555	0.568 0.569	0.574	0.557 0.555	0.570 0.570	0.590	0.559 0.544	0.560	2.38
	4-MIN. WIPED WIRE.																			
7	Front end of reel	0.694 0.687	0.686 0.697	0.705 0.679	0.683	0.683 0.708	0.697	0.689	0.703 0.696	0.694	0.705 0.723	0.705	0.747	0.748 0.744	0.687	0.713 0.711	0.765 0.768	0.719	0.725	4.47
8	Center of reel..	0.651 0.651	0.655	0.645 0.647	0.650 0.675	0.661 0.646	0.652 0.646	0.647	0.640	0.651	0.668 0.656	0.649 0.670	0.701	0.699	0.651	0.673	0.714	0.655 0.658	0.672	3.22
9	Rear end of reel	0.668 0.687	0.679 0.716	0.712 0.653	0.683	0.679 0.671	0.665	0.675	0.694 0.666	0.680	0.699 0.694	0.692	0.712	0.692 0.699	0.669	0.722 0.701	0.738 0.787	0.685	0.701	3.09
	UNWIPED WIRE.																			
10	Front end of reel	1.093 1.196	1.242	1.146	1.197 1.248	1.155 1.192	1.195 1.144	1.224 1.172	1.178	1.184	1.172 1.203	1.240 1.222	1.250 1.200	1.212	1.206	1.222	1.292	1.184 1.200	1.217	2.78
11	Center of reel..	1.196 1.233	1.239 1.222	1.316	1.340	1.264 1.262	1.299 1.313	1.259	1.259 1.292	1.263	1.397 1.288	1.394	1.187 1.341	1.271 1.362	1.287	1.335	1.432 1.368	1.314	1.334	5.60
12	Rear end of reel	1.069 1.166	1.164	1.138	1.243 1.092	1.195 1.191	1.149 1.076	1.144 1.105	1.152	1.145	1.178 1.160	1.185	1.142 1.228	1.182	1.194	1.211	1.236	1.244 1.140	1.191	4.02

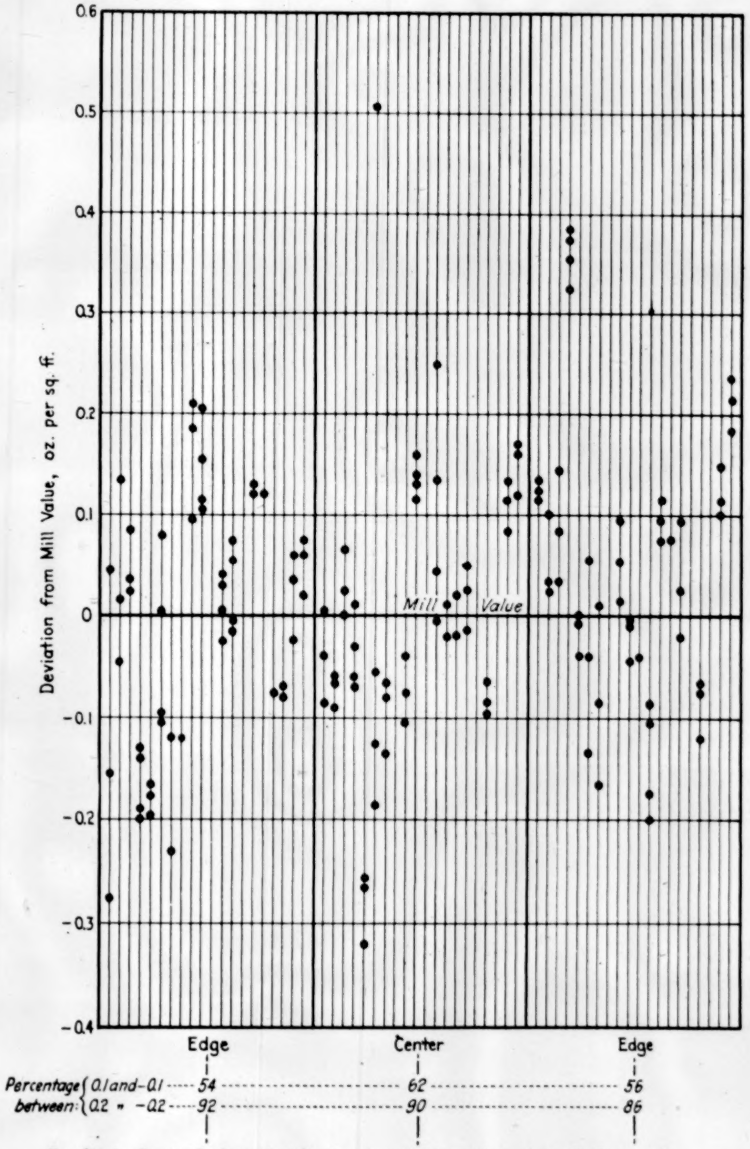
TABLE III.—SUMMARY OF RESULTS OF TESTS ON WIRE.

Sample No.	Description.	Average Weight of Zinc Coating, oz. per sq. ft. of actual surface.		Deviation of Average Weight of Coating from Weight of Coating of Entire Reel, per cent.	
		Basic-Lead-Acetate Method.	Hydrochloric Acid-Antimony Chloride Method.	Basic-Lead-Acetate Method.	Hydrochloric Acid-Antimony Chloride Method.
	2-MIN. WIPED WIRE.				
1	Front end of reel.	0.396	0.427	−0.174	−0.466
2	Center of reel....	0.392	0.413	−2.73	−3.73
3	Rear end of reel..	0.420	0.447	+4.22	+4.20
Average of reel...	....	0.403	0.429		
	3-MIN. WIPED WIRE.				
4	Front end of reel.	0.584	0.596	+3.36	+2.05
5	Center of reel....	0.563	0.596	−0.35	+2.05
6	Rear end of reel..	0.547	0.560	−3.19	−4.10
Average of reel...	....	0.565	0.584		
	4-MIN. WIPED WIRE.				
7	Front end of reel.	0.694	0.725	+2.82	+3.72
8	Center of reel....	0.651	0.672	−3.56	−3.86
9	Rear end of reel..	0.680	0.701	+0.74	+0.28
Average of reel...	....	0.675	0.699		
	UNWIPED WIRE.				
10	Front end of reel.	1.184	1.217	−1.08	−2.4
11	Center of reel....	1.263	1.334	+5.3	+6.9
12	Rear end of reel..	1.145	1.191	−4.33	−4.48
Average of reel...	....	1.197	1.247		



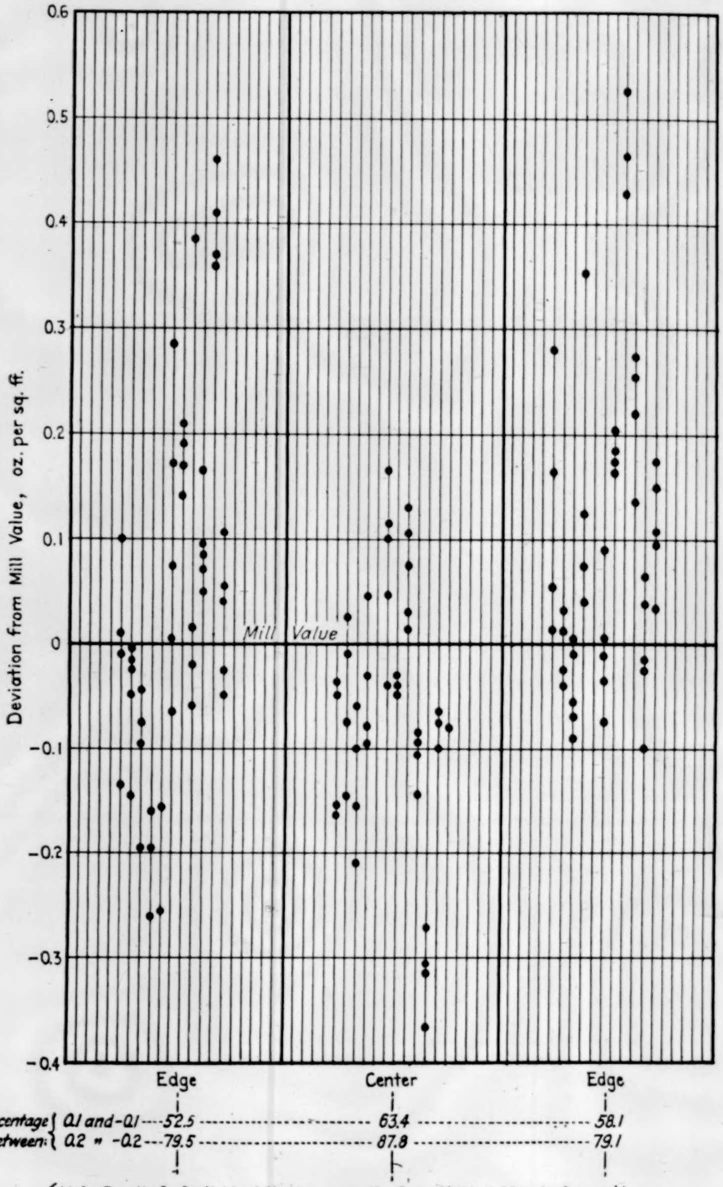
(Note: Results for Individual Sheets are on the Same Vertical Line in General.)

FIG. 2.—Deviation of Individual Determinations from Mill Value for "S" Sheets; Basic-Lead-Acetate Method.



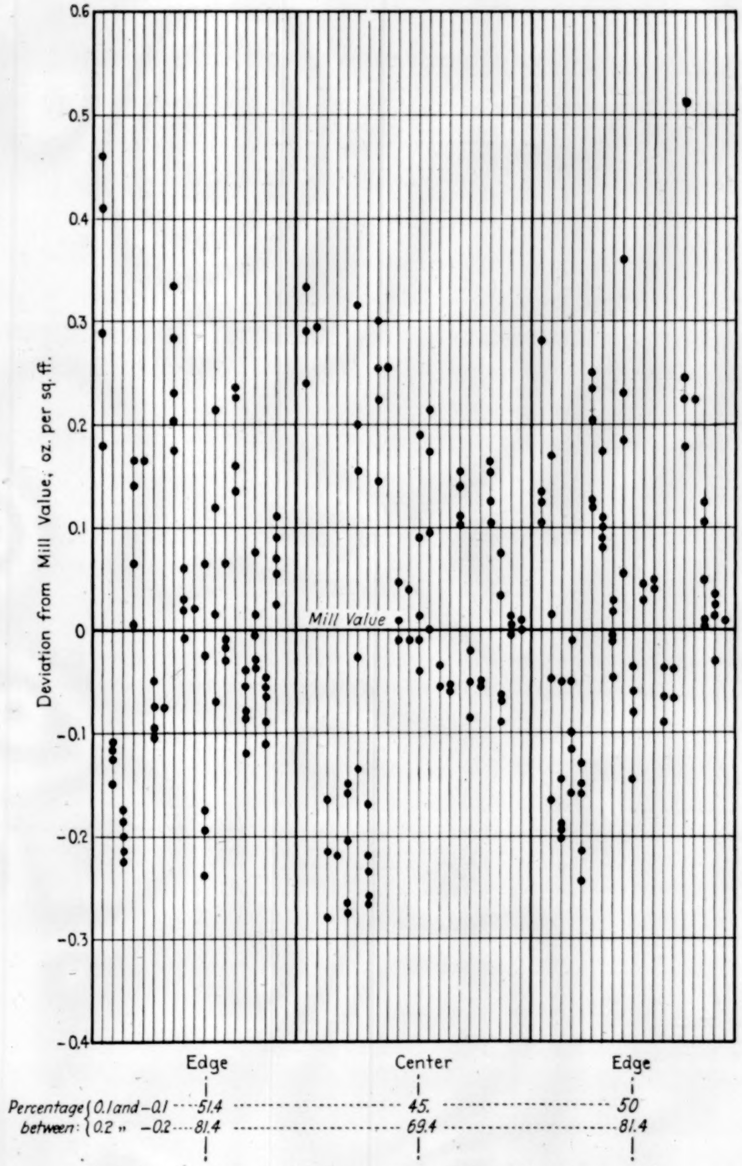
(Note: Results for Individual Sheets are on the Same Vertical Line in General.)

FIG. 3.—Deviation of Individual Determinations from Mill Value for "R" Sheets; Basic-Lead-Acetate Method.



(Note: Results for Individual Sheets are on the Same Vertical Line in General.)

FIG. 4.—Deviation of Individual Determinations from Mill Value for "S" Sheets; Hydrochloric Acid - Antimony Chloride Method.



(Note: Results for Individual Sheets are on the Same Vertical Line in General.)

FIG. 5.—Deviation of Individual Determinations from Mill Value for "R" Sheets; Hydrochloric Acid - Antimony Chloride Method

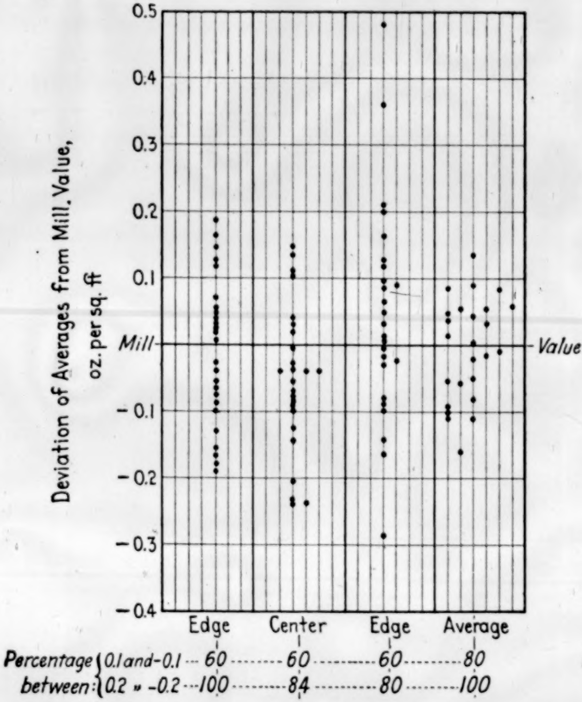


FIG. 6.—Deviation of Averages of Individual Determinations from Mill Value for Sheets; Basic-Lead-Acetate Method.

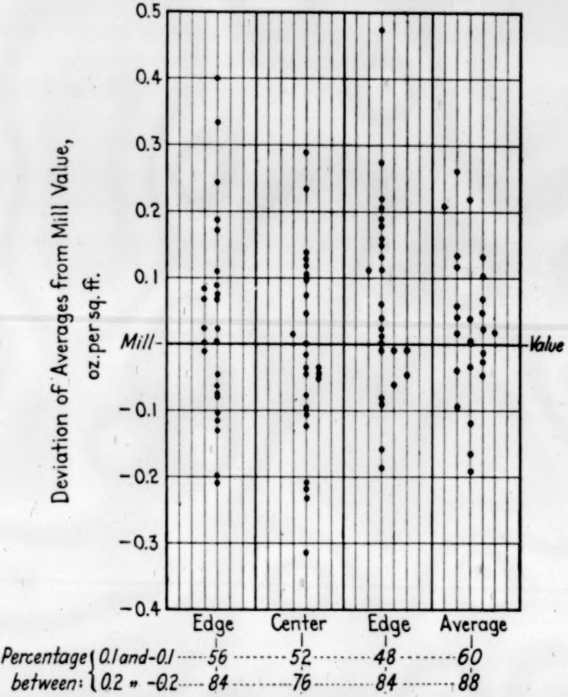


FIG. 7.—Deviation of Averages of Individual Determinations from Mill Value for Sheets; Hydrochloric Acid - Antimony Chloride Method.

DISCUSSION OF RESULTS.

1. The deviations of individual determinations, by either method, of the coatings of sheets are so varied that no general conclusion can be drawn other than the obvious one that the sheet should not be judged by any one single sample. Figs. 2 to 7, inclusive, show graphically the deviation of the results of the individual determinations from the "mill value" or actual weight of coating, and also the averages for each of the three positions, "edge, center, edge," as well as the sheet average. The relatively close agreement of the average of the sheet with the mill value is evidence of the desirability of using the method of sampling employed for the sheet material. The sheet averages obtained by the basic-lead-acetate method agree somewhat more closely with the mill value than do those by the other method. (See Figs. 8 and 9.) For 92 per cent of the 25 sheets examined by the basic-lead-acetate method, the sheet average agrees with the mill value within 6 per cent. Of the same number (25) examined by the second method, 68 per cent of the sheet

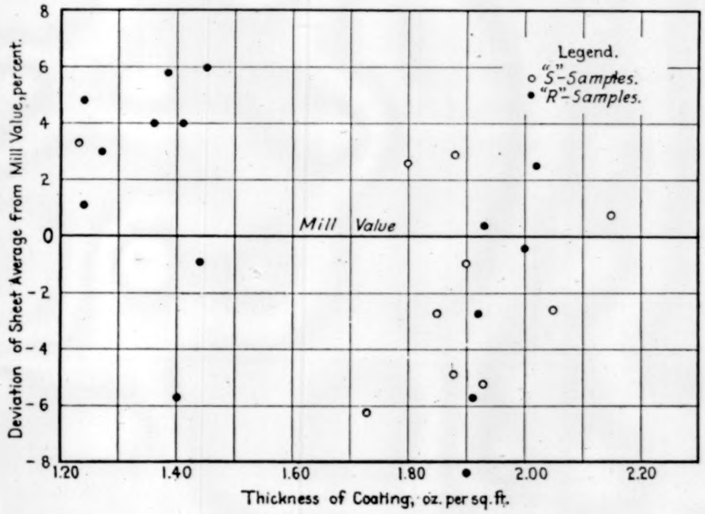


FIG. 8.—Percentage Deviation of Average of Individual Determinations from Mill Value for Sheets; Basic-Lead-Acetate Method.

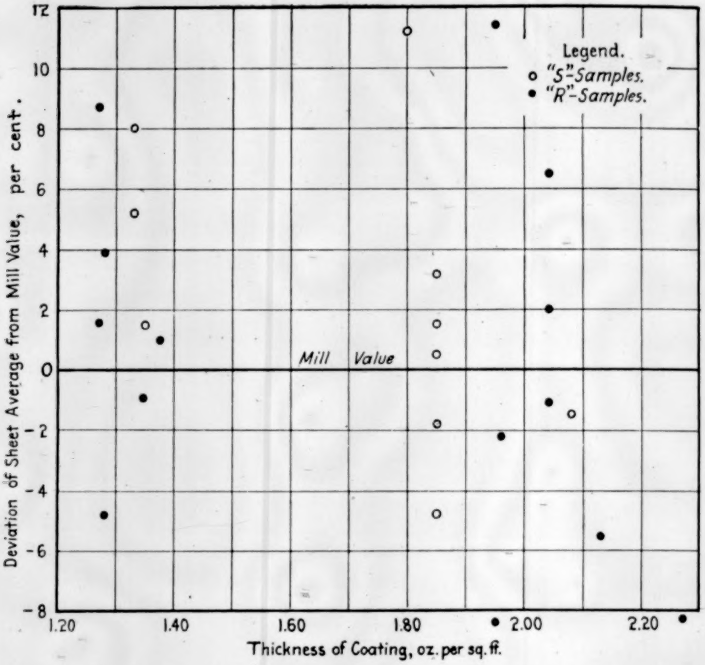


FIG. 9.—Percentage Deviation of Average of Individual Determinations from Mill Value for Sheets; Hydrochloric Acid - Antimony Chloride Method.

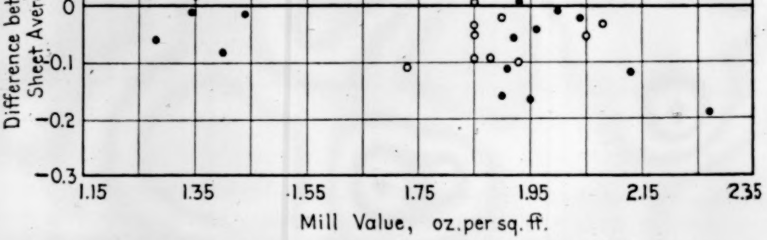


FIG. 10.—Relation between Mill Value and the Difference between Mill Value and Sheet Average.

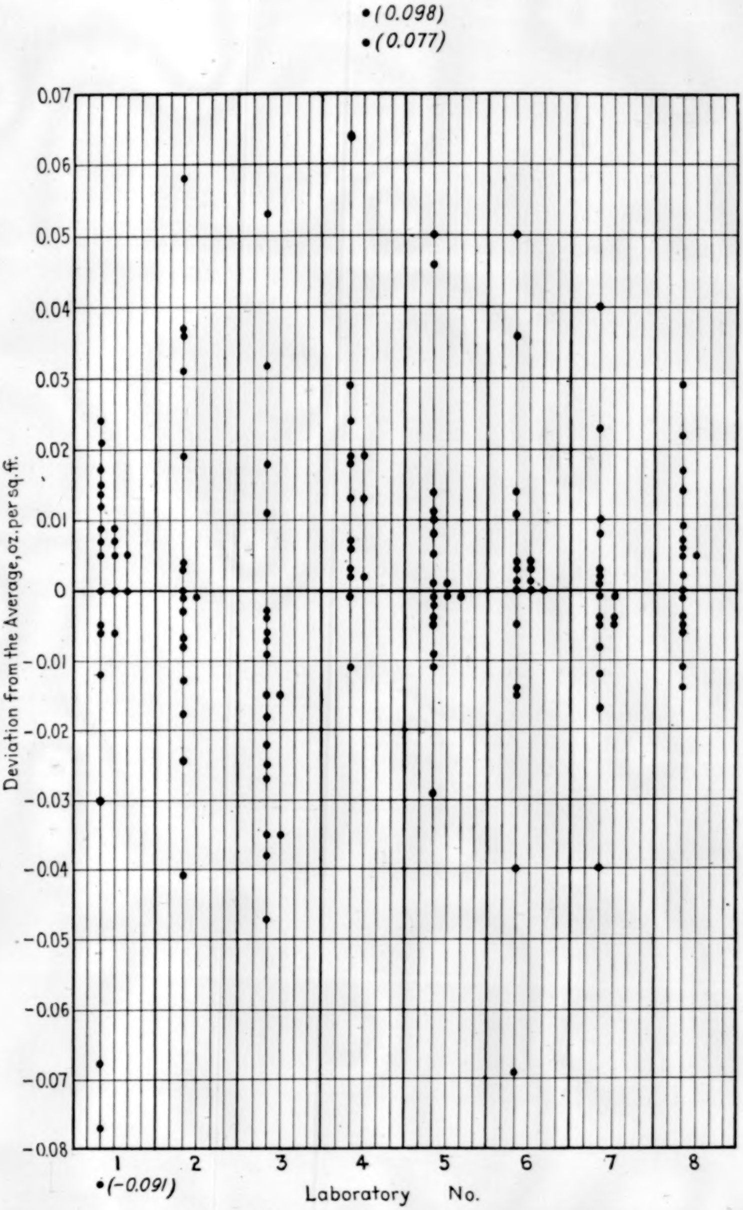


FIG. 11.—Deviation of Individual Determinations on Wires from the Average; Basic-Lead-Acetate Method.

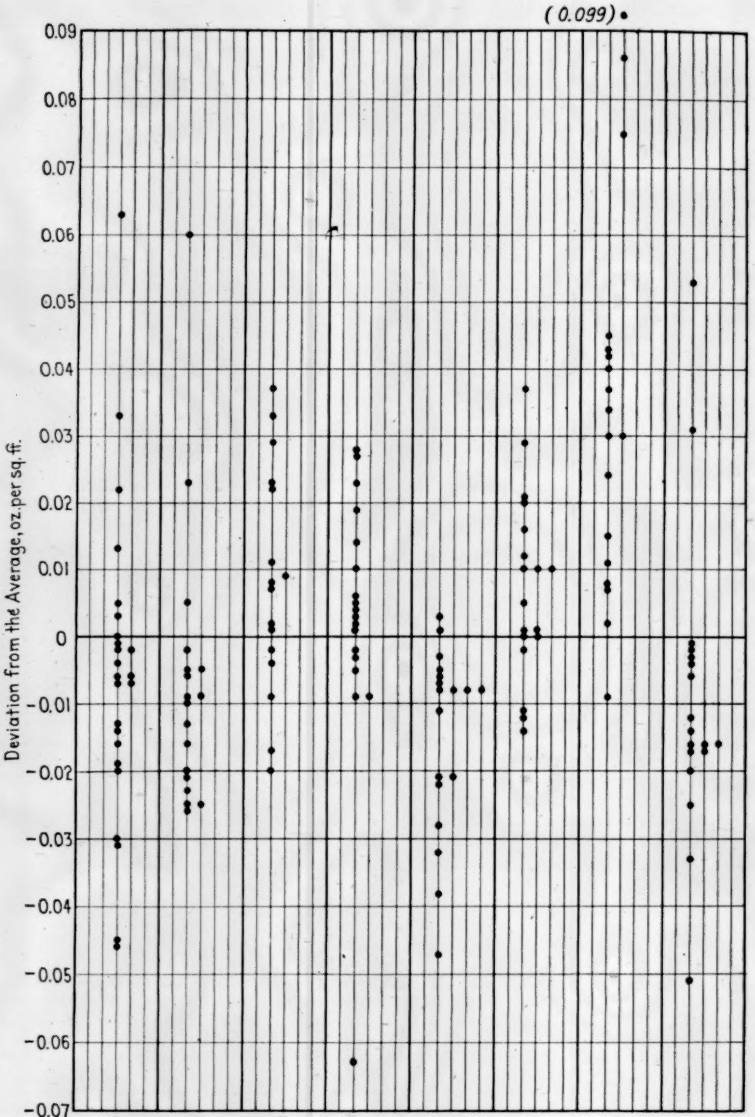


FIG. 12.—Deviation of Individual Determinations on Wires from the Average; Hydrochloric Acid - Antimony Chloride Method.

averages fall within the same limits. No comparison of the averages with the actual amount of zinc by weight (mill value) was possible in the case of the wire samples. In every case, however, the averages obtained by the hydrochloric acid - antimony chloride immersion are invariably higher than by the basic-lead-acetate method; from 2.3 to 7.8 per cent.

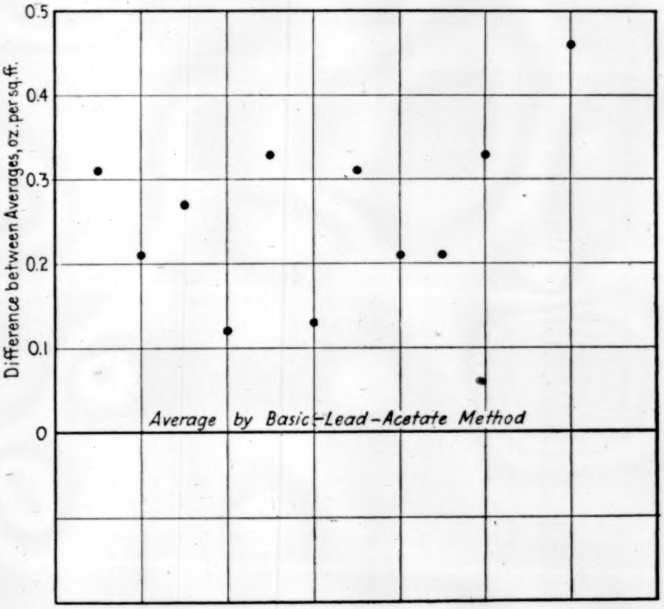


FIG. 13.—Difference between Averages on Wires obtained by the Two Methods.

2. In general the hydrochloric acid - antimony chloride method gives results slightly higher than the basic-lead-acetate method. The average deviation of the sheet averages obtained by removing the coating in lead acetate is 1.9 per cent below the mill value; the other method gives an average deviation of the sheet average from the mill value of +3.5 per cent. It should be noted, however, that these results were obtained upon different sheets.

The differences observed in the case of wires—in which case the same material was tested by both methods—is also in the same direction. The average difference between the averages for all the samples as determined by the two methods is 4.4 per cent, the average obtained by the basic-lead-acetate method in every case being the lower one (Fig. 13).

3. The gage of the sheet in itself is a minor factor and may be disregarded in the discussion, as shown in Table IV.

The thickness of the coating applied, however, is adapted to the gage of the sheet. According to the thickness of coating (mill value), the sheets examined may be grouped into two classes of approximately 1.35 and 1.95 oz. The average of more thinly coated sheets is somewhat more than the corresponding mill value (+0.059 oz.); the average of the other group corresponds very closely to the mill value (−0.018 oz.) (Fig. 8). To the attack of the base metal may be attributed, in part at least, the higher values obtained for the thinly coated sheets, that is, higher gage. The slightly low results obtained for material which was more heavily coated, that is, lower gage, suggests that traces of the zinc not entirely removed by the stripping will account for the result.

TABLE IV.—RELATION OF GAGE TO THICKNESS OF COATING.

Number of Samples.	Kind of Sample.	Gage No.	Average Deviation of Sheet Average from Mill Value, per cent.
10..................	S sheets	16	−3.28
10..................	S sheets	26	+4.37
14..................	R sheets	16	−4.90
2..................	R sheets	20	+3.93
4..................	R sheets	22	+4.65
4..................	R sheets	24	+7.33
6..................	R sheets	26	+3.05

4. Figs. 11 and 12, showing the results obtained for wires—

in which case all of the laboratories examined each of the samples —illustrates the personal equation in the use of each of the two methods, and the tendency of the results of any one worker to run consistently high or low, that is, with reference to the average obtained by all of the laboratories.

Comparative Advantages of Methods.—The obvious advantage of the basic-lead-acetate method over the second one is that it may be used to locate local thin spots (similar to the Preece test), and also gives the total weight of coating as does the hydrochloric acid - antimony chloride method. One great disadvantage is the difference of time required, which may be as much as 40 to 1 in favor of the second method. The hydrochloric acid - antimony chloride method is to be preferred for the general ease of manipulation (other than the mere time concerned), but can be used for but the one determination, that is, total thickness of coating of the sample.

Accuracy of Determinations.—The mill value which has been used as a basis of comparison for the sheets is the difference in weight between the black and the coated sheet. The weighings of the individual sheets were made at the mill and were stated to be accurate to 0.5 oz. For a sheet 96 by 120 in. containing 2 oz. per sq. ft. this amounts to an error of only 0.31 per cent. In thinly coated sheets (1 oz. per sq. ft.), the percentage is correspondingly higher (0.62 per cent).

The $2\frac{1}{4}$-in. squares which are cut from the sheets should be sheared accurately to $\frac{1}{64}$ in. An error of this amount on two edges is equivalent to an error of approximately 0.7 per cent in area. Measurements of the two dimensions of 24 of the S samples gave a deviation of the average dimension of +0.001 in. from 2.25 in. This is equivalent to an error in area of 0.07 per cent. Similar measurements upon 35 R samples gave a deviation of the average dimension of +0.024 in. from 2.25 in.; error in area equals 2.1 per cent. An error of $\frac{1}{32}$ in. in 9 in. length of wire (which was the length of sample used) is equivalent to 0.35 per cent error. The wires were cut while clamped tightly in a press and the ends filed squarely down to 9 in. This length was accurate to within $\frac{1}{32}$ in.

RECOMMENDATIONS AND SUGGESTIONS FOR TESTING.

1. The sub-committee recommends both the basic-lead-acetate and the hydrochloric acid - antimony chloride method for determining the total coating of hot-dipped galvanized materials; the slight tendency of the second method to "run high" should be borne in mind, however. For determining the small local spots of minimum thickness, the first method should be used.

2. Sheets should be sampled according to the method used in this work and outlined diagrammatically in Fig. 1. At least three samples from each sheet should be tested, that is, one from each position (edge, center, edge). Such samples should be $2\frac{1}{4}$ in. square, accurate to $\frac{1}{64}$ in., if it is desired to have loss of weight in grams per sample numerically equal to the weight in ounces per square foot of sheeting (that is, 2 sq. ft. of coating).

Wires may be sampled from either end of the reel and should be cut accurately to length, while tightly clamped in a suitable press, within $\frac{1}{64}$ in.

Though no work was done upon pipes, it is recommended that such material be sampled at each end, a 2-in. length being used.

3. For sheets, it is recommended that results are preferably expressed in units of weight per square foot of *actual* surface, that is, 1 sq. ft. of sheet galvanized on both sides should be calculated as 2 sq. ft. of area and not 1 sq. ft., as at present.

For wires, the results should be expressed in units of weight of coating per unit area of surface, and also per unit of length.

For coating on pipes, the coating should be expressed in units of weight of coating per unit of actual surface.

4. As yet no permissible variation or rejection limit is to be recommended for sheets. In fixing any such limit two sources of error should always be considered:

(*a*) The accuracy of the method of testing, which is limited by differences due to variations in sampling, variations in the thickness of the coating across the sheet, errors due to personal equation, etc., amounts to from 6 to 8 per cent of the actual amount of zinc as determined by weighing individual sheets before and after coatings.

(*b*) The unavoidable variations in mill practice give rise to variations in the weight of coating of different sheets, presumably of the same weight of coating, of a magnitude equal at least to that of the accuracy of the method used in testing.

COMPARISON OF METHODS OF SAMPLING.

The following results obtained by the American Rolling Mill Co. illustrate the most efficient and representative method of sampling:

The black sheet was first weighed and then weighed after galvanizing, in order to determine the amount of spelter coating actually applied. The sheets were then sampled at the points shown in Fig. 14.

Each of the nine samples was analyzed separately in order to determine the average, minimum, and maximum weights of coating on representative portions of the sheet. Table V shows the amount of coating actually applied, determined by weighing the sheets before and after galvanizing; the average results obtained on nine samples taken as above described, and the average of samples Nos. 4, 5 and 6, these being the three samples from the middle portion of the sheet. The maximum and minimum weights of coating of the nine samples are also given.

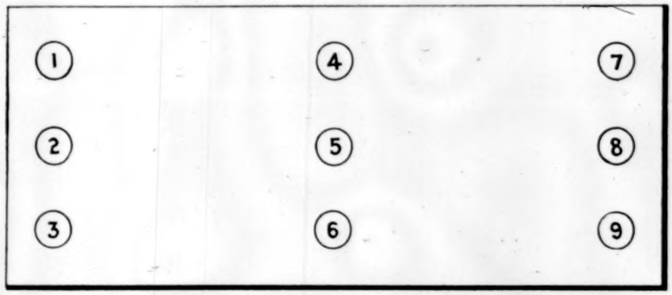


Fig. 14.—Method of Sampling used by American Rolling Mill Co.

The hydrochloric acid - antimony chloride method, as noted in Table V, was used in determining the weight of coating on the samples. It will be seen that the variation on various portions of the same sheet in some instances amounts to more than 0.6 oz. per sq. ft. The results obtained by this method are somewhat lower than the actual amount of coating applied, which can be accounted for by not having analyzed any samples containing galvanized edges.

Inasmuch as it would be extremely difficult to take nine samples from a sheet and average them as shown in Table V, the method has been adopted of making one test on the combined samples Nos. 4, 5 and 6, taken from the middle portion of the sheet, which, as is seen from Table V, shows a very close average agreement with either the results obtained by weighing the sheet before and after galvanizing or those obtained by the analysis of nine samples.

TABLE V.—WEIGHTS OF COATING DETERMINED BY HYDROCHLORIC ACID-ANTIMONY CHLORIDE METHOD.

Weight of Coating, oz. per sq. ft.				
Actual Weight by Weighing Sheet.	Average of Nine Tests.	Average of Samples Nos. 4, 5 and 6.	Maximum of Nine Tests.	Minimum of Nine Tests.
2.08	2.10	2.10	2.32	1.68
1.98	1.93	2.00	2.08	1.78
2.06	1.99	1.90	2.21	1.83
2.06	1.99	1.80	2.51	1.72
1.76	1.77	1.73	1.81	1.63
2.05	1.97	1.88	2.14	1.82
1.70	1.76	1.74	1.82	1.71
1.67	1.61	1.60	1.68	1.50
1.80	1.84	1.71	1.95	1.54
2.23	1.95	1.84	2.40	1.73
2.02	2.05	2.02	2.33	1.84
1.88	1.78	1.66	2.05	1.56
2.02	1.73	1.66	1.93	1.56
2.27	2.34	2.39	2.47	2.20
2.36	2.23	2.19	2.45	1.92
2.30	2.32	2.28	2.52	2.23
2.42	2.20	2.15	2.35	2.06
1.98	2.03	2.00	2.26	1.88
2.55	2.33	2.43	2.49	2.21
2.03	2.00	1.93	2.14	1.87
2.14	2.16	2.12	2.37	2.02
2.19	2.07	2.05	2.21	2.00
2.10	1.96	1.89	2.42	1.79
2.56	2.46	2.54	2.63	2.32
2.10	2.14	2.16	2.23	2.03
1.93	1.88	1.87	2.03	1.67
1.54	1.57	1.58	1.71	1.47
2.12	1.90	1.75	2.34	1.71
1.89	1.76	1.69	2.00	1.60
2.18	2.04	2.09	2.48	1.98
1.61	1.68	1.70	1.87	1.50
Average of 31 sheets.. 2.05	1.99	1.95		

ATTACK OF BASE METAL.

A short series of weighings were made by laboratory No. 1 (Bureau of Standards) to illustrate the attack of the base metal of sheets and wires in each of the two methods. These are given in Tables VI, VII, VIII and IX. In each case the time indicated, for example, 10 minutes, means 10 minutes *additional.* The attack of the base metal due to the lead acetate is entirely negligible; the sheets used had previously been stripped and weighed. The apparently greater attack during the first immersion (5 minutes) should undoubtedly be attributed to small amounts of zinc still adhering.

TABLE VI.—ACTION OF BASIC-LEAD-ACETATE SOLUTION ON BASE METAL OF SHEETS.

Sample No.	Initial Weight, g.	First Immersion.		Second Immersion.		Third Immersion.	
		Weight after 5 min. in Solution, g.	Loss, g.	Weight after 10 min. in Solution, g.	Loss, g.	Weight after 30 min. in Solution, g.	Loss, g.
R-25—A-3.....	12.5367	12.5352	0.0015	12.5354	(0.0002)	12.5352	0.0000
R-1—B-2......	12.5092	12.5075	0.0017	12.5076	(0.0001)	12.5075	0.0000
R-1—B-3......	12.4400	12.4377	0.0023	12.4371	0.0006	12.4363	0.0008
R-29—A-1.....	16.8922	16.8886	0.0036	16.8885	0.0001	16.8880	0.0005
R-23—B-1.....	19.1425	19.1401	0.0024	19.1402	(0.0001)	19.1402	0.0000
S-5—B-4......	13.6630	13.6620	0.0010	13.6617	0.0003	13.6610	0.0007
S-9—B-5......	12.9584	12.9574	0.0010	12.9573	0.0001	12.9573	0.0000
S-9—B-4......	12.8754	12.8740	0.0014	12.8739	0.0001	12.8734	0.0005
S-3—A-2......	12.8800	12.8794	0.0006	12.8793	0.0001	12.8791	0.0002
S-3—B-5......	13.1735	13.1725	0.0010	13.1725	0.0000	13.1724	0.0001
Average.......	....	....	0.00165	....	0.00015	....	0.00028

TABLE VII.—ACTION OF HYDROCHLORIC ACID - ANTIMONY CHLORIDE SOLUTION ON BASE METAL OF SHEETS.

Sample No.	Initial Weight, g.	First Immersion.		Second Immersion.		Third Immersion.	
		Weight after 1 min. in Solution, g.	Loss, g.	Weight after 10 min. in Solution, g.	Loss, g.	Weight after 20 min. in Solution, g.	Loss, g.
R-29—A-2.....	17.2523	17.2450	0.0073	17.2384	0.0066	17.2318	0.0066
R-27—A-2.....	11.5560	11.5499	0.0061	11.5442	0.0057	11.5401	0.0041
R-27—A-3.....	11.9625	11.9574	0.0051	11.9504	0.0070	11.9459	0.0045
R-23—B-3.....	19.6205	19.6172	0.0032	19.6087	0.0085	19.6061	0.0026
R-5—A-3......	23.2705	23.2656	0.0049	23.2585	0.0071	23.2546	0.0039
S-4—A-3......	12.7250	12.7222	0.0028	12.7186	0.0036	12.7145	0.0041
S-4—C-4......	12.8543	12.8511	0.0032	12.8480	0.0031	12.8424	0.0056
S-4—B-1......	13.4734	13.4707	0.0027	13.4645	0.0062	13.4579	0.0066
S-5—B-3......	13.5783	13.5654	0.0085	13.5654	0.0044	13.5553	0.0101
S-7—C-2......	12.9534	12.9442	0.0092	12.9354	0.0088	12.9300	0.0054
Average.......	....	....	0.0053	....	0.0061	....	0.00537

A comparison of the determination of the loss due to attack of the base metal, of wires previously stripped and dried and of unstripped wires (Tables VIII and IX), shows that the metal is attacked much more readily immediately after stripping, than it is after being cleaned and dried before immersing in the acid a second time.

TABLE VIII.—ACTION OF HYDROCHLORIC ACID - ANTIMONY CHLORIDE SOLUTION ON BASE METAL OF UNSTRIPPED WIRES.

Sample No.	Initial Weight, g.	First Immersion.		First Immersion.		Average Weight of Zinc Coating, g.	Loss due to Attack of Base Metal, g.
		Weight after 5 min. in Solution,[a] g.	Loss, g.	Weight after 10 min. in Solution,[a] g.	Loss, g.		
W-1-e.......	19.8184	19.2900	0.5284	....	......	0.349	0.1794
W-3-e.......	20.2045	19.6535	0.5510	....	......	0.342	0.2090
W-4-e.......	19.6065	19.0050	0.6015	....	......	0.480	0.1215
W-6-e.......	19.4342	18.8387	0.5955	....	......	0.454	0.1415
W-9-e.......	20.2370	19.5726	0.6644	....	......	0.465	0.1994
W-10-f......	20.5385	19.4385	1.1000	....	......	0.960	0.1400
W-11-f......	20.7713	19.5765	1.1948	....	......	1.052	0.1428
Average.....	....	....	....	....	....	....	0.1619
W-3-f.......	20.2117	....	......	19.4884	0.7233	0.342	0.3813
W-4-f.......	19.6276	....	......	18.9231	0.7045	0.480	0.2245
W-5-f.......	19.5695	....	......	18.8505	0.7190	0.480	0.2390
W-9-f.......	20.1687	....	......	19.2955	0.8732	0.465	0.4080
W-10-e......	20.5510	....	......	19.3235	1.2275	0.960	0.2675
W-11-e......	20.7445	....	......	19.4837	1.2608	1.052	0.2088
Average.....	....	....	....	....	....	....	0.2882

[a] Includes stripping.

TABLE IX.—ACTION OF HYDROCHLORIC ACID - ANTIMONY CHLORIDE SOLUTION UPON BASE METAL OF WIRES WHICH HAD BEEN PREVIOUSLY STRIPPED, CLEANED AND DRIED.

Sample No.	Initial Weight, g.	First Immersion.		Second Immersion.		Total Loss after First and Second Immersions, g.	First Immersion.	
		Weight after 5 min. in Solution, g.	Loss, g.	Weight after 15 min. in Solution. g.	Loss, g.		Weight after 15 min. in Solution, g.	Loss, g.
W-1-b.....	19.5066	19.5035	0.0031	19.4984	0.0051	0.0082	....	......
W-4-d.....	19.0652	18.9850	0.0802	18.9796	0.0054	0.0856	....	......
W-6-a.....	18.9984	18.9970	0.0014	18.9930	0.0040	0.0054	....	......
W-7-d.....	19.3746	19.2405	0.1341	19.2361	0.0044	0.1385	....	......
W-8-a.....	19.5634	19.5620	0.0014	19.5584	0.0036	0.0050	....	......
Average...	....	....	0.0440	....	0.0045			
W-1-a.....	19.4389	....	......	....	......	......	19.4336	0.0053
W-4-a.....	19.1936	....	......	....	......	......	19.1918	0.0018
W-6-b.....	19.0602	....	......	....	......	......	19.0582	0.0020
W-7-b.....	19.3290	....	......	....	......	......	19.3253	0.0037
W-8-b.....	19.5562	....	......	....	......	......	19.5538	0.0024
Average...	....	....	....	....	....	....	....	0.0030

DISCUSSION.

Mr. W. A. Slater.—I have had occasion to make determinations of the amount of corrosion on reinforcement when subjected to different kinds of exposure, and in looking for a method by which to do this, I have been surprised at the lack of any detailed statement of how it may be done satisfactorily. I should like to ask if Committee A-5 would consider it feasible and within their province to recommend a method by which, under given conditions, the amount of corrosion may be measured. What I mean by saying under given conditions is under conditions in which the exposure varies and not in which the material which is being corroded is supposed to vary. Of course I understand that the material will vary, but I believe that in the cases I am considering, the greatest variation is in the method of exposure. Committee C-11 on Gypsum of this Society is working on recommendations for designs of reinforced gypsum and no method of measuring corrosion under the conditions I have outlined has been accepted as standard. **Mr. Slater.**

The Chairman (Mr. J. H. Gibboney).—I am sure that Committee A-5 will be glad to give very serious consideration to this question raised by Mr. Slater. Is there any further discussion of the report? **The Chairman.**

Mr. C. G. Brown.—With reference to the zinc coating on wire: if that is translated into so much weight of zinc per square foot, isn't there danger of introducing a larger error than some of the other errors, due to the fact that a slight change in the size of the wire would make a very appreciable percentage of change in the area? For example, if the wire is assumed to be 0.1 in. in diameter, and is actually a little different in diameter, would not that throw the computations out quite appreciably? **Mr. Brown.**

Mr. S. S. Voorhees (*Chairman of Committee A-5*).—Mr. Brown's question is answered by the fact that the determinations recorded are averages of a number of results obtained by testing a large quantity of wire. Isn't that correct, Mr. Rawdon? **Mr. Voorhees.**

Mr. Rawdon. MR. H. S. RAWDON.—Yes, the differences in the results on wire were much less than in those on sheets. In the report it is recommended that results for wires may preferably be expressed in units of weight per square foot of actual area or actual length.

The Chairman. THE CHAIRMAN.—It is common knowledge to all of us that the present day specification for sheet metal places the requirement for weight of coating per square foot not on actual surface but on the two surfaces of the sheet, and this interpretation of the term "surface" is generally understood. Will some manufacturer of sheet metal state whether or not in his judgement the introduction of this change from the present practice of applying the term will introduce a disturbing factor in specification interpretation? Surely if the change is adopted we shall have to revise our requirements in existing specifications and we should certainly qualify the use of the term "surface" in such a way as to avoid any misunderstanding as to its meaning.

Mr. Carnahan. MR. R. B. CARNAHAN, JR.—Some confusion always occurs when changes are made in commercial or trade terms. However, if the manufacturers of this country would cooperate in the movement it would be possible to quickly eliminate the irregularities of expression used when referring to the weight of spelter coating on iron or steel products. Simplicity and clearness of expression in trade terms are highly desirable, and it is the duty of manufacturers to foster all movements in this direction.

Mr. Voorhees. MR. VOORHEES.—I think all of us who have been using this measure of coating for sheets have felt the ambiguity of our expression and heartily support this movement, but I think that in order to prevent mistakes, it will be necessary, for a while at least, to say "This applies to one side," or to use such a phrase as will show just what is intended.

Mr. Carnahan. MR. CARNAHAN.—Mr. Slater spoke of the desirability of having a quantitative method for determining corrosion. I have been searching for this for years, but have not yet found a satisfactory method. I refer especially to sheets, although I understand Mr. Slater refers to reinforcing rods.

When a roof fails it is because a large number of holes have appeared, not because it has corroded evenly all over. In other words, uneven corrosion has brought about failure. **Mr. Carnahan.**

In tracing the production of a finished sheet or wire from the raw material, there are many stages where physical defects and bad mill practice may prove more disastrous than incorrect chemical analysis. Good metal in the open-hearth department may be injured by improper pouring temperature and by the use of dirty molds; too rapid reduction in the blooming mill results in cracks and seams; improper heating and rolling in the finishing mill produces defective product. When these facts are considered it is evident that a method for the determination of corrosion, based on loss in weight in a given time, cannot be considered reliable. If some quantitative method for the determination of corrosion could be worked out so that the results obtained would be truly comparable to say ten years of actual service, such a method would prove of enormous value to those of us who are endeavoring to produce superior corrosion-resisting material.

Mr. Slater. MR. SLATER.—The point has been brought out, which made me state in my previous discussion that it was variation in conditions of exposure rather than variation in the material itself that I had in mind. Using the illustration that Mr. Carnahan gave, if from one of those ingots in which the material is presumably uniform throughout, different samples be exposed to, we will say, concrete which is very dense, concrete which is not very dense, concrete which has salt in its make-up, and gypsum or any other conditions of exposure we are trying to study, and from these samples the comparative losses by weight are determined, will we not have arrived at something which will give us a basis for concluding how to correct the difficulty due to corrosion in any given circumstances? Is that an impossible or nearly impossible problem? Does not that view of it simplify the question?

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS.

At the meeting of Committee B-2 held in April, 1917, reports from the six sub-committees were presented and discussed.

Sub-Committee I on Pure Metals in Ingot Form.—Mr. W. H. Bassett, chairman, presented proposed revisions in Standard Specifications for Spelter (B 6–14) to supplement those submitted last year. These were accepted by the committee and referred to letter ballot. They are appended to this report (Appendix I), with the recommendation that the specifications in their revised form be published for one year among the Tentative Standards of the Society.[1]

The sub-committee is now working on specifications for lead.

Sub-Committee II on Wrought Metals and Alloys.—Mr. W. R. Webster presented the following two specifications:

1. Proposed Tentative Specifications for Brass Forging Rod;
2. Proposed Tentative Specifications for Free-Cutting Brass Rod for Use in Screw Machines.

These specifications were accepted by the committee and referred to letter ballot. They are appended to this report[2] with the recommendation that they be published as tentative in accordance with the by-laws.

Sub-Committee III on Sand-Cast Metals and Alloys.—Mr. W. M. Corse, chairman, presented the report of this sub-committee which has been collecting data according to the plan outlined last year. This report is embodied in Appendix II to this report and gives the results of tests on various alloys.

Sub-Committee IV on White Metals.—Mr. G. H. Clamer, chairman, stated for this sub-committee that it is highly desirable that no specifications for white metals shall be recommended until standard methods of analysis and sampling are agreed upon. It is hoped that a newly appointed sub-committee on Methods of Analysis can aid in drawing up tentative methods of analysis, so that by next year satisfactory specifications can be formulated.

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[1] See pp. 615–621.—Ed.

[2] See pp. 603–609.—Ed.

Sub-Committee V on Plates, Tubes and Staybolts for Locomotives.—Mr. W. R. Webster, chairman, reported that there are no changes to offer in the four proposed tentative specifications submitted last year.

Sub-Committee VI on Non-Ferrous Alloys for Railway Equipment.—Mr. G. H. Clamer, chairman, presented proposed Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings and Finished Car and Tender Bearings. They are appended to this report[1] with the recommendation that they be published as tentative in accordance with the by-laws.

A new Sub-Committee VII on Methods of Analysis has been formed under the chairmanship of Mr. W. A. Cowan.

Another new Sub-Committee VIII on Aluminum Alloys, Cast and Wrought, has been formed on account of the need for such work in aeroplane manufacture.

The analysis of the returns from the letter ballot is as follows:

Proposed Standard.	Affirmative.	Negative.	Not Voting.
Proposed Tentative Specifications for Spelter	30	3	11
Proposed Tentative Specifications for Brass Forging Rod	27	0	17
Proposed Tentative Specifications for Free-Cutting Brass Rod for Use in Screw Machines	27	2	15
Proposed Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings and Finished Car and Tender Bearings	32	0	12

This report has been submitted to letter ballot of the committee which consists of 44 members, of whom 33 have voted affirmatively, none negatively, and 11 have refrained from voting.

Respectfully submitted on behalf of the committee,

William Campbell,
Chairman.

Editorial Note.

For Addendum to this report, see page 195.

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[1] See pp. 610–614.—Ed.

APPENDIX I.

PROPOSED REVISIONS
IN
STANDARD SPECIFICATIONS FOR SPELTER.[1]

At the last annual meeting Committee B-2 presented certain revisions in the Standard Specifications for Spelter, which were published in the Proceedings[2] as tentative. The committee desires to supplement these revisions by the following additional revisions, and recommends that the specifications in their completely revised form be published for one year among the Tentative Standards of the Society:

1. *Section 1.*—To provide for Electrolytic Spelter, after the word "distillation" add the words "or by electrolysis;" and in order to follow established custom, instead of the letters A, B, C, D and E, use the numbers 1, 2, 3, 4 and 5 respectively, to designate the grades of spelter.

2. *Section 4.*—Change the limit for cadmium in High-Grade spelter from 0.05 to 0.07 per cent.

Change the limit for lead in Prime Western Grade spelter from 1.50 to 1.60 per cent, and the limit for iron from 0.06 to 0.08 per cent.[3]

3. *Section 6.*—In the proposed revised wording submitted at the last annual meeting, change the first word "select" to "take."

4. *Section 8.*—Change the word "mill" to "plant" wherever it occurs.

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[1] Standard Specifications for Spelter (Serial Designation: B 6–14), 1916 Book of A. S. T. M. Standards, p. 423.

[2] Vol. XVI, Part I, p. 583 (1916).

[3] This change in the limit of iron refers to the revision proposed last year, which was to change the limit from 0.08 to 0.06 per cent. The net effect is, therefore, to leave the requirement as it now stands in the specifications (see 1916 Book of A. S. T. M. Standards, p. 424).

5. *Section 10.*—Change the second paragraph from its present form, namely:

> "On a question of metal contents an adequate sample shall be drawn by the representatives of both parties; the sample shall be prepared from the slabs so selected as described under 'Sampling.' The sample shall be mixed and separated into three parts, each of which shall be placed in a sealed package, one for each party and one for the umpire if necessary. Each party shall make an analysis and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality and whose determination shall be final,"

to read as follows:

> "On a question of metal contents a sample shall be drawn by representatives of both parties as described under 'Sampling,' Section 6. The properly mixed and quartered sample shall be separated into three parts, each of which shall be placed in a sealed package, one for each party and one for an umpire if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality, and whose determination shall be final."

6. *Section 11.*—Change the word "maker" to "seller."

7. Add the following footnotes to the specifications:

(*a*) Under Section 4, High Grade:

> "For slush castings and certain zinc-aluminum alloys, a special grade of spelter may be required, as noted in 'Spelter, Its Grades and Uses,' published as Appendix I to the report of Committee B-2, *Proceedings*, Am. Soc. Test. Mats., Volume XVI, Part I, p. 183 (1916)."

(*b*) Under Section 7, Cadmium:

> "Care should be taken that the solution of the sample proceeds slowly, particularly toward the last, and that the stated amount of spelter remains in the undissolved residue."

APPENDIX II.

REPORT OF SUB-COMMITTEE III
ON
SAND-CAST METALS AND ALLOYS.

Following the decision of Committee B-2 to accumulate data on various alloys from reliable sources, Sub-Committee III submits the results together with the descriptive letters from different authorities.

No attempt has been made to prepare specifications but the data are given as results which can be obtained when these alloys are cast by the methods described. The insistent demand for information of this character would seem to indicate the need of publication of preliminary work of this kind.

It is a well-known fact that these physical properties, while comparative for the alloys under consideration, cannot be expected to represent the physical properties of the metal in a casting. These figures cannot be used by engineers to calculate the strength of the materials, except with a liberal factor of safety, because the physical properties of a casting are dependent largely on its size and form. In the opinion of the sub-committee the values for tensile strength and yield point of actual castings are but 50 per cent of those values obtained with test bars.

The reports from the various authorities are as follows:

PROPERTIES OF THE ALLOY: COPPER, 88 PER CENT; TIN, 10 PER CENT; ZINC, 2 PER CENT.

DATA FROM L. P. WEBBERT.

This alloy is commonly known as 88-10-2 alloy, Government Bronze, U. S. Navy Gun Bronze, Government Composition G. In England it is known as Admiralty Gun Metal, Gun Metal, Gun Bronze.

Chemical Composition.—The alloy contains:

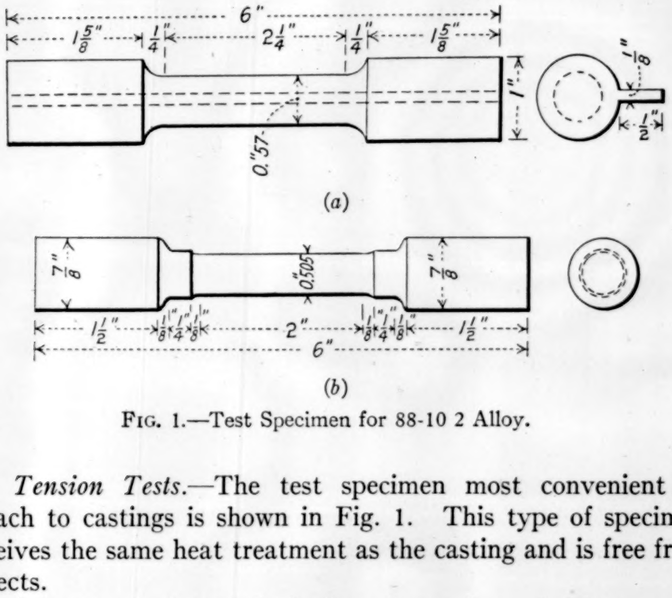
Copper..................................	87 – 89 per cent.
Tin......................................	9 – 11 "
Zinc.....................................	1 – 3 "

The impurities present in this alloy are iron (not exceeding 0.10 per cent), sulfur (not exceeding 0.05 per cent), and lead (not exceeding 0.50 per cent). Aluminum and antimony are not allowed to be present in this alloy even in small quantities.

The presence of a small quantity of lead, not over 0.50 per cent, improves the machining qualities of this metal.

Physical Properties.—The physical properties of this alloy are as follows:

Specific gravity at 20° C. (68° F.)	8.7
Weight per cubic inch	0.314 lb.
Brinell hardness number, 500 kg. load, 10 mm. ball (sand-cast metal, unannealed)	70
Scleroscope hardness number	12 – 15.


6"
$1\frac{5}{8}$"
$\frac{1}{4}$"
$2\frac{1}{4}$"
$\frac{1}{4}$"
$1\frac{5}{8}$"
1"
$\frac{1}{8}$"
$\frac{1}{2}$"
0."57
$\frac{7}{8}$"
0.505"
$\frac{7}{8}$"
$1\frac{1}{2}$"
$\frac{1}{8}$" $\frac{1}{4}$" $\frac{1}{8}$"
2"
$\frac{1}{8}$" $\frac{1}{4}$" $\frac{1}{8}$"
$1\frac{1}{2}$"
6"

(*a*)

(*b*)

FIG. 1.—Test Specimen for 88-10 2 Alloy.

Tension Tests.—The test specimen most convenient to attach to castings is shown in Fig. 1. This type of specimen receives the same heat treatment as the casting and is free from defects.

A test specimen 0.505 in. in diameter, as shown in Fig. 1, would represent quite closely the strength of a casting of $\frac{1}{2}$ in. thickness. A test specimen 0.798 in. in diameter, similar to the specimen of 0.505 in. in diameter, would give a lower tensile strength and would represent quite closely the strength of a casting $\frac{3}{4}$ in. thick.

The highest tension test observed using this type of test specimen was 58,450 lb. per sq. in. with an elongation in 2 in. of 55.5 per cent. Specifications[1] allow a minimum tensile strength of 33,000 lb. per sq. in. and a minimum elongation in 2 in. of 14 per cent.

Linear contraction from liquid to solid, using a bar 12 by 1 by 1 in., in. per ft	0.13
Melting point	995° C. (1825° F.)
Casting temperature	1175 – 1245° C. (2150 – 2275° F.)

Thick castings take the lower temperature. Thin castings take the higher temperature. Temperatures are taken at the furnace.

Distribution of Strength in a Casting.—The designer of a casting should note that the average strength of a thick casting in pounds per square inch is lower than that of a thin casting.[2] This is due to the fact that the surface of a casting, commonly called the skin, possesses the highest tensile strength. From the skin inward the tensile strength and elongation decrease. A test specimen of the type shown in Fig. 1 attached to a casting may give a tensile strength of 40,000 lb. per sq. in., whereas a test specimen cut from the interior of the same casting may give a tensile strength as low as 25,000 lb. per sq. in. The designing engineer should pay particular attention to those parts of a casting where the skin is removed in machining, leaving the weaker metal.

Heat Treatment.—The test specimen, as shown in Fig. 1, attached to a casting is practically a cast-to-size test coupon and gives a higher tensile strength than the average strength of the casting. The specimen receiving the same heat treatment as the casting affords a means of examining the heat treatment received by the casting. Fig. 2 shows the appearance of the surface of eight test specimens, selected from a large number of castings, after being pulled. These castings were made in dry sand and allowed to cool in the mold. The specimens are arranged to show the relation existing between the condition of the surface of the pulled test specimen and the heat treatment

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[1] Tentative Specifications for the Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent; pp. 585–587.—ED.

[2] Webbert, "Study of the Strength of Non-Ferrous Castings: Comparison of Different Test Specimens," *Proceedings*, Am. Soc. Test. Mats., Vol. XIV, Part II, p. 145 (1914).

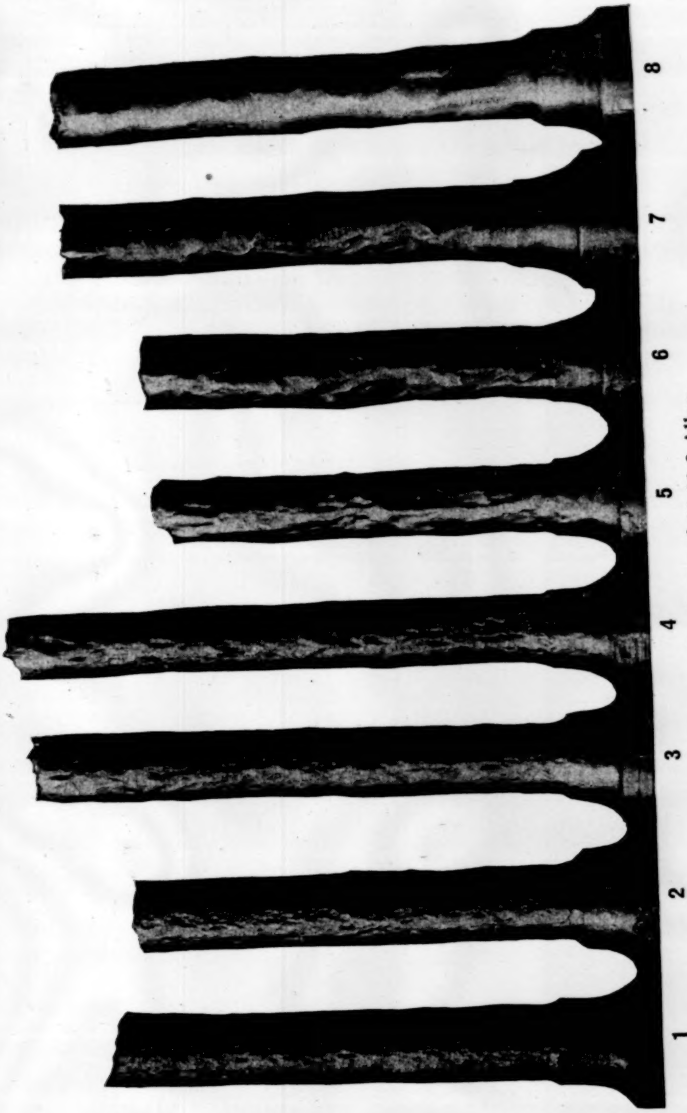

FIG. 2.—Specimens of 88-10-2 Alloy.

received. It has been shown that a similar relation exists between the surface of a steel test specimen after being pulled and the heat treatment received. The casting temperatures of specimens Nos. 6, 7 and 8 were too high. With specimen No. 1, the heat introduced into the mold approaches the amount necessary to anneal the casting properly. Beyond specimen No. 1, the specimens show decreasing tensile strength and elongation, and at the extreme end, if we could complete the arrangement of specimens, we find specimens showing a grayish fracture with very low elongation and showing an almost smooth test specimen.

Table I gives the physical properties of the specimens.

TABLE I.—PHYSICAL PROPERTIES OF SPECIMENS SHOWN IN FIG. 2.

Specimen No.	Yield Point,[1] lb. per sq. in.	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent.
1..............	18 500	54 500	53
2..............	18 000	52 800	50
3..............	19 500	52 000	61
4..............	17 500	51 000	56.5
5..............	17 000	50 300	57.5
6..............	17 500	47 400	49
7..............	18 500	41 300	29
8..............	18 500	40 000	29.5

[1] The dividers were used in obtaining the yield point. The values given are approximate.

PROPERTIES OF MANGANESE BRONZE.

DATA FROM G. H. CLAMER.

The chemical analyses of eight typical manganese-bronzes are as follows:

	MAXIMUM.	MINIMUM.	AVERAGE.
Copper, per cent..............	59.80	57.44	58.72
Zinc, per cent................	40.26	37.59	39.05
Tin, per cent.................	1.03	0.59	0.79
Iron, per cent................	1.39	0.80	1.06
Manganese, per cent...........	0.05	0.03	0.038
Aluminum, per cent............	0.80	0.19	0.47
Lead, per cent................	0.20	0.05	0.12

For tension tests, the sand-cast specimens were taken from the bottom of regulation wedge form of test block, and the chill samples were cut from the bottom of ingot cast in open mold. The physical properties determined are as follows:

Tensile strength, lb. per sq. in.	Sand cast	70 000 – 75 000
	Chill cast	75 000 – 80 000
Elongation in 2 in., per cent	Sand cast	22 – 30
	Chill cast	25 – 32
Weight, sand cast, lb. per cu. in		0.3009
Shrinkage, in. per ft		¼

DATA FROM J. L. JONES.

Tests for the electrical conductivity for manganese bronze gave the following results:

At 23° C	27.7 per cent
At 21°.8 C	27.4 "
At 21°.6 C	27.5 "

Results of 22 tests for Brinell hardness on 3 samples were are follows:

Maximum	113.6
Minimum	96.3
Average	105.0

DATA FROM N. K. B. PATCH.

The chilled cast bar used was made from a 1-in. square bar poured in an open chill and then machined to size. The sand cast bar was cut from the standard A.S.T.M. No. 4 bar with three coupons.

Following are the physical properties of the bars:

	SAND CAST.	CHILL CAST.
Tensile strength, lb. per sq. in	70 000 – 75 000	75 000 – 80 000
Elongation in 2 in., per cent	22 – 30	25 – 32
Brinell hardness	109 – 119	119 – 130
Specific gravity	8.4	....
Weight per cubic inch, lb	0.30	....
Electric conductivity, per cent, about	22	....
Modulus of elasticity, lb. per sq. in.	14 000 000	....
Shrinkage, in. per ft	¼	....

DATA FROM J. A. CAPP.[1]

Manganese-bronze castings were supplied in the form of cylindrical bars about 1½ in. in diameter and 24 in. long. They were machined to about 1 in. in diameter and 8 in. long between shoulders for extensometer tests; or about ½ in. in diameter and 2 in. long between shoulders for commercial tests. The results are given in Table II.

TABLE II.—RESULTS OF TESTS ON MANGANESE-BRONZE BARS.

Bar No.	Extensometer Test.			Commercial Test.			
	Elastic Limit, lb. per sq. in.	Modulus of Elasticity, lb. per sq. in.	Elongation in 8 in., per cent.	Yield Point, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent.	Reduction of Area, per cent.
9902 *B*......	16 000	12 390 000	31.6	26 000	69 650	32.5	40.8
9902 *B*......	15 000	12 900 000	27.5	....	....	....	....
9902 *A*......	21 400	....	27.2	25 000	67 940	42.0	54.8
9902 *A*......	16 000	13 000 000	27.8	....	....	....	....
9908 *B*......	23 000	13 300 000	10.6	29 000	80 420	26.5	28.5
9908 *A*......	22 900	....	6.6	26 000	70 900	14.5	22.4

PROPERTIES OF THE ALLOY: COPPER, 80 PER CENT; TIN, 10 PER CENT; LEAD, 10 PER CENT.

DATA FROM N. K. B. PATCH.

The physical properties for both sand-cast and chill-cast specimens of the 80-10-10 alloy are given in Table III.

Referring to Table III, specimen No. 1 was tested by the Lumen Bearing Co. This alloy contained 0.2 per cent of phosphorus. The sand-cast specimen was made from cast-to-shape standard 2 in. by 0.505-in. test bar. Tests on chill-cast specimen made on 1 in. square test bar machined to standard 2 in. by 0.505-in. bar, cast in iron mold.

Specimen No. 2 was tested by the Ajax Metal Co. The tests on this specimen were made from block cast in sand, specimens machined before testing. The test block was gated at the bottom, the upper part of the wedge being of cross-section to act as ample riser.

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[1] Capp, "The Elastic Limit of Manganese and Other Bronzes," *Proceedings*, Am. Soc. Mech. Engrs., Vol. 32, pp. 507–520 (1910).

TABLE III.—PHYSICAL PROPERTIES OF THE ALLOY: COPPER, 80 PER CENT; TIN, 10 PER CENT; LEAD, 10 PER CENT.

SAND CAST.

Physical Property.	Specimen No. 1.	Specimen No. 2.	Specimen No. 3.	Specimen No. 4.	Average.	Minimum.	Maximum.
Tensile strength, lb. per sq. in........	26 000 - 32 000	33 130	30 000 - 37 000	30 000 av.	31 407	26 000	37 000
Yield point, lb. per sq. in............	21 000 - 26 000	....	16 000 - 23 000	20 000 av.	21 200	16 000	26 000
Elongation in 2 in., per cent.........	4 - 8	28	5 - 18	8	13.6	4	28
Reduction in area, per cent.........	4 - 9	28.08	6 - 16	9	12.02	4	28.08
Brinell hardness....	61 - 70	....	55 - 60	71	63	55	71
Specific gravity.....	8.9	8.8[a]	9.0	8.70	8.85	8.7	9.0
Weight per cubic inch, lb..........	0.322	0.3182	0.33	0.314	....	....	....
Shrinkage per foot, in...............	0.125	0.125	0.125	0.122	....	....	....
Elastic limit in compression, lb. per sq. in............	15 000	23 000	1 150 - 1 200	....	....	....	....
Elastic limit in tension, lb. per sq. in.	....	19 020	....	13 500	....	....	....
Compression per square inch, at 15,000 lb., in. per inch............	0.001	....	....	....	....	....	....
Compression per square inch at 50,000 lb., in. per inch............	0.100	....	....	....	....	....	....
Compression per square inch at 100,000 lb., in. per inch.........	....	....	0.30 - 0.35	....	....	....	....
Coefficent of expansion, per deg. Cent from 1-100......	....	....	0.0000188	0.0000187	....	....	....
Electric conductivity, per cent....	....	....	....	6.5	....	....	....
Resistance, microhms per cu. in...............	....	....	....	9.656	....	....	....
Melting point, deg. Cent............	....	....	....	872	....	....	....

[a] Calculated from weight per cubic inch of 0.3182 lb.

CHILL CAST.

Physical Property.	Specimen No. 1.	Specimen No. 2.	Specimen No. 3.	Specimen No. 4.	Average.	Minimum.	Maximum.
Tensile strength, lb. per sq. in........	36 000 - 42 000	....	30 000 - 33 000	....	35 250	30 000	42 000
Yield point, lb. per sq. in............	23 000 - 29 000	....	....	....	26 000	23 000	29 000
Elongation in 2 in., per cent.........	2 - 6	....	4 - 7	....	4.5	2	7
Reduction of area, per cent.........	1 - 6	....	....	....	3.5	1	6
Brinell hardness....	80 - 89	....	....	....	85	80	89

Specimen No. 3 was tested by the Titanium Alloys Co. Tests on sand-cast specimens were made on bars cast to shape. No record of bar used for chill cast.

Specimen No. 4 was tested by the Westinghouse Electric and Manufacturing Co. This alloy contained 0.35 per cent of phosphorus. Tests were made from standard 2 in. by 0.505-in. test bar machined from sand-cast specimen. Hardness tests were made on specimen 2 in. in diameter by ¾ in. thick.

It should be noted that the variation in elongation and reduction of area as given by the different tests would indicate some slight variation in the analyses or composition of the material. This may be explained by the difference in the amount of phosphorus used as a deoxident or it may be possible that some of the manufacturers use another deoxidizing agent which has no hardening effect.

PROPERTIES OF 10-PER-CENT ALUMINUM BRONZE.

DATA FROM W. M. CORSE.

The chemical composition of three specimens was as follows:

	SPECIMEN. No. 1.	SPECIMEN. No. 5.	SPECIMEN. No. 13.
Copper, per cent	90	89	90
Aluminum, per cent	10	10	9.9
Iron, per cent	..	1	..

Results of tension tests on bars cast-to-size in sand, about ½ in. in diameter and 2 in. long between shoulders, are as follows:

	SPECIMEN. No. 1.	SPECIMEN. No. 5.	SPECIMEN. No. 13.[a]
Proportional limit, lb. per sq. in.	.....	19 800	.....
Yield point, lb. per sq. in.	24 000	24 000	25 000
Tensile strength, lb. per sq. in.	70 000	77 000	71 000
Elongation in 2 in., per cent	20	24	21
Reduction of area, per cent	20	25	.....

Results of compression tests on cylinders 1 in. long and 1 sq. in. in cross-section, machined from bars about 1½ in. square, are as follows:

	SPECIMEN. No. 1.	SPECIMEN. No. 5.
Load giving compression of 0.1 per cent, lb. per sq. in.	19 500	19 000
Compression at load of 100,000 lb. per sq. in., per cent	12	15

---

[a] From Eighth Report, British Inst. Mech. Engrs.

Various other physical properties were as follows:

	Specimen. No. 1.	Specimen. No. 5.	
Brinell hardness	90 – 100	95 – 105	
Scleroscope hardness	....	25	
Shrinkage, in. per ft	0.22	0.22	
Weight per cu. in., lb	0.27	0.27	
Specific gravity at 20° C	7.5	7.5	
Coefficient of friction	0.0018	.....	
Coefficient of expansion, per deg. Cent	0.0000171	....	
Electric conductivity at 20° C., per cent	....	18.39	(by mass)
	....	15.47	(by volume)

Endurance Tests in White-Souther Machine.

Revolutions at 36,000 lb. per sq. in., max	1 000 000
Revolutions at 27,000 lb. per sq. in., max	10 000 000

PROPERTIES OF THE ALLOY: ALUMINUM, 92 PER CENT; COPPER, 8 PER CENT.

Data from J. L. Jones.

Following are physical properties of the alloy of aluminum and copper as determined in three laboratories:

	Westinghouse Elec. Co.	Bureau of Mines.	Lumen Bearing Co.
Tensile strength, lb. per sq. in.:			
Chilled	....	....	20 000 – 24 000
Sand	19 800	....	16 000 – 20 000
Poured hot	....	15 500	....
Poured cold	....	20 000	....
At 500° F	....	19 300	....
Yield point, lb. per sq. in	15 400	....	....
Elastic limit, lb. per sq. in	5 000	13 000	....
Elongation in 2 in., per cent	0.8	1.5	1 – 2
Reduction of area, per cent	4.9	....	....
Transverse strength, lb. per sq. in.	....	290	....
Transverse deflection, in	....	0.22	....
Impact resistance, blows:			
4.7-lb. hammer	300	....	....
2.3-lb. hammer	7 000	....	....
Brinell hardness	50	....	....
Specific gravity	2.83	2.84	2.8

	WESTINGHOUSE ELEC. CO.	BUREAU OF MINES.	LUMEN BEARING CO.
Weight per cu. in., lb	0.102	....	0.10
Shrinkage, in	0.175[a]	....	$\frac{3}{16}$[b]
Coefficient of expansion per deg. Cent., 0 to 100°	0.0000240	....	....
Resistance, microhms per cu. in	1.609	....	....
Conductivity, per cent	39	....	....
Machining qualities	....	soft and gummy	....
Hot shortness:			
At 1300° F	....	235[c]	....
At 1500° F	....	90[c]	....

DATA FROM L. W. SPRING (CRANE CO.).

Following are the physical properties of various alloys. The brick test bars and the single bars referred to are illustrated in Figs. 3 and 4, respectively.

ALLOY "A": TIN, 2 PER CENT; LEAD, 10 PER CENT; COPPER, 78 PER CENT; ZINC, 10 PER CENT.

Pot No.	Chemical Analysis, per cent.	Style of Bars.	Tensile Strength, lb. per sq. in.	Elastic Limit, lb. per sq. in.	Elongation in 2 in., per cent.	Reduction of Area, per cent.
1[d]	Sn...... 2.21	Brick Pattern...	28 900	10 740	35.94	33.75
	Pb...... 9.77	" " ...	29 000	12 230	35.94	34.30
	Cu...... 77.82	Single Bar......	27 500	13 200	18.75	23.25
	Fe...... 0.35	" "	28 300	11 200	20.31	25.65
	Zn...... 9.42	Flaw Single Bar.	24 000	13 000	12.50	21.60
2	Sn...... 2.48	Brick Pattern...	24 400	10 300	25.00	26.00
	Pb...... 10.04	" " ...	24 100	10 600	23.44	20.12
	Cu...... 78.00	Single Bar......	25 750	13 250	15.62	19.70
	Fe...... 0.21	" "	24 600	13 000	12.50	20.80
	Zn...... 9.40		.....	.....	.....	.....

---

[a] In 12 by 1 by 1-in. bar.

[b] Inches per foot.

[c] Norton, *Transactions*, Am. Inst. Metals, Vol. 8, p. 124 (1914).

[d] By actual determination, specific gravity = 8.87; weight per cubic inch = 145.2 g.

ALLOY "B": TIN, 5 PER CENT; LEAD, 5 PER CENT; COPPER, 85 PER CENT; ZINC, 5 PER CENT.

Pot No.	Chemical Analysis, per cent.	Style of Bars.	Tensile Strength, lb. per sq. in.	Elastic Limit, lb. per sq. in.	Elongation in 2 in., per cent.	Reduction of Area, per cent.
1	Sn...... 4.88	Brick Pattern...	31 250	15 800	26.56	24.90
	Pb...... 4.91	" " ...	32 150	15 800	29.69	22.25
	Cu...... 84.92	Single Bar......	34 000	19 700	18.75	22.80
	Fe...... 0.21	Flaw Single Bar.	27 600	16 700	9.38	20.25
	Zn...... 4.74	Single Bar......	36 000	17 850	23.44	24.25
2	Sn...... 5.33	Brick Pattern...	25 500	.....	18.75	24.25
	Pb...... 4.44	" " ...	26 300	14 300	20.31	20.80
	Cu...... 85.48	Single Bar......	33 750	16 300	23.44	17.20
	Fe...... 0.21	" "......	31 600	.....	18.75	14.70
	Zn...... 4.57	" "......	30 900	17 350	15.62	19.00

ALLOY "C": TIN, 12 PER CENT; COPPER, 88 PER CENT.

Pot No.	Chemical Analysis, per cent.	Style of Bars.	Tensile Strength, lb. per sq. in.	Elastic Limit, lb. per sq. in.	Elongation in 2 in., per cent.	Reduction of Area, per cent.
1	Sn...... 13.24	Brick Pattern...	36 000	24 150	4.68	4.73
	Pb...... 0.63	" " ...	34 700	23 800	4.68	5.88
	Cu...... 84.88	Single Bar......	41 400	25 620	3.12	3.67
	Fe...... 0.42	" "......	42 200	27 350	4.68	5.10
	Zn...... 0.39		.....	.....	....	....

ALLOY "D": TIN, 10 PER CENT; COPPER, 88 PER CENT; ZINC, 2 PER CENT.

Pot No.	Chemical Analysis, per cent.	Style of Bars.	Tensile Strength, lb. per sq. in.	Elastic Limit, lb. per sq. in.	Elongation in 2 in., per cent.	Reduction of Area, per cent.
1	Sn...... 10.79	Brick Pattern...	28 950	18 810	12.50	13.80
	Pb...... 0.16	" " ...	30 600	18 080	15.62	15.25
	Cu...... 86.84	Single Bar......	35 600	22 700	7.81	8.18
	Fe...... 0.21	" "......	36 200	22 350	7.81	9.71
	Zn...... 1.99		.....	.....	....	....

ALLOY "E".

Pot No.	Chemical Analysis, per cent.	Style of Bars.	Tensile Strength, lb. per sq. in.	Elastic Limit, lb. per sq. in.	Elongation in 2 in., per cent.	Reduction of Area, per cent.
1	Sn...... 3.94	Brick Pattern...	31 000	14 640	25.00	26.40
	Pb...... 6.49	" " ...	31 600	15 790	26.56	32.80
	Cu...... 82.96	Single Bar......	34 200	16 920	25.00	26.00
	Fe...... 0.42	" "......	32 510	16 700	21.87	22.20
	Zn...... 6.35		.....	.....	.....	.....

ALLOY "F".

Pot No.	Chemical Analysis, per cent.	Style of Bars.	Tensile Strength, lb. per sq. in.	Elastic Limit, lb. per sq. in.	Elongation in 2 in., per cent.	Reduction of Area, per cent.
1	Sn...... 0.55	Brick Pattern...	61 500	21 900	42.19	42.30
	Pb...... 0.52	" " ...	62 000	22 350	42.19	42.50
	Cu...... 59.60	Single Bar......	47 350	22 850	9.38	18.40
	Fe...... 2.16	" "	48 750	23 350	10.94	20.80
	Zn...... 37.20		.....	.....	.....	.....
2	Sn...... 0.82	Brick Pattern...	64 900	24 800	35.94	35.80
	Pb...... 0.48	" " ...	65 000	25 500	35.94	35.80
	Cu...... 59.10	Single Bar......	51 000	27 300	9.38	19.30
	Fe...... 2.29	" "	50 000	26 800	9.38	18.40
	Zn...... 36.94		.....	.....	.....	.....

ELECTRICAL CONDUCTIVITY AT 20° C. (J. L. JONES).

Alloy A, No. 1	22.0	Alloy D, No. 1	11.6
" B "	16.4	" E "	20.7
" C "	9.3	" F "	24.6

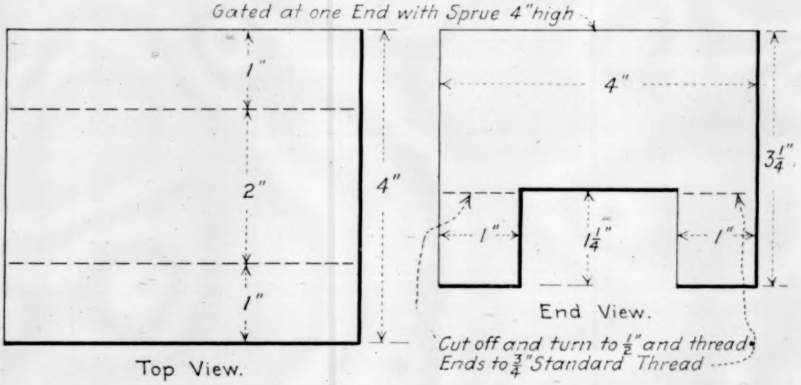
Gated at one End with Sprue 4" high
1"
2"
1"
4"
4"
$3\frac{1}{4}$"
1"
$1\frac{1}{4}$"
1"
End View.
Cut off and turn to $\frac{1}{2}$" and thread Ends to $\frac{3}{4}$" Standard Thread
Top View.

FIG. 3.—Brick Test Bars.

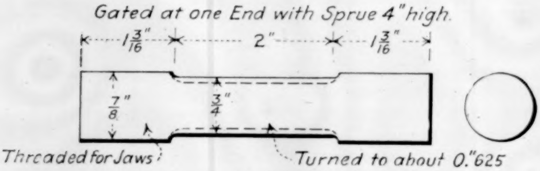
Gated at one End with Sprue 4" high.
$1\frac{3}{16}$"
2"
$1\frac{3}{16}$"
$\frac{7}{8}$"
$\frac{3}{4}$"
Threaded for Jaws
Turned to about 0."625

FIG. 4.—Single Bars.

ADDENDUM

TO

REPORT OF COMMITTEE B-2.

Subsequent to the preparation of the report of Committee B-2 and its distribution in preprint form to the members of the Society, Mr. W. A. Cowan, Chairman of the newly organized Sub-Committee VII on Methods of Analysis, prepared proposed Methods for Analysis of Alloys of Lead, Tin, Antimony and Copper which are appended hereto.[1] Although there has been no opportunity to submit these Methods to letter ballot of the committee, it is recommended that they be accepted for publication among the Tentative Standards of the Society provided a subsequent letter ballot of the committee on them should be carried without a dissenting vote.

The committee also recommends that the Tentative Specifications for Seamless Brass Boiler Tubes (B 14–16 T)[2] be amended by the insertion at the end of Section 3 on "Chemical Composition" of the words: "zinc......remainder."

Editorial Note.

The four proposed tentative specifications referred to in this report were accepted for publication among the Tentative Standards of the Society, and appear on pages 603–621.

The result of the letter ballot on the proposed Tentative Methods for Analysis of Alloys of Lead, Tin, Antimony and Copper, referred to in the Addendum to the report, was affirmative without a dissenting vote, and the Methods therefore appear among the Tentative Standards of the Society on pages 621–629.

The recommended revision in the Tentative Specifications for Seamless Brass Boiler Tubes, referred to in the Addendum, was approved.

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[1] See pp. 621–629.—Ed.

[2] See pp. 599–602.—Ed.

REPORT OF COMMITTEE C-1

ON

CEMENT.

Committee C-1 has held two meetings since the last annual meeting of the Society, the attendance and discussions at which fully demonstrated the interest of the various members in the work of the committee. It might have been expected after the marked activity of all of the members during the previous year, that there would be some abatement of the general interest and the work during the present year. The reports of the various sub-committees show, however, that the active work in securing and compiling data is continuing very enthusiastically.

The work of Sub-Committees III, VI and VII on Fineness, Time of Setting, and Strength, respectively, has progressed to such a degree that these sub-committees are now either waiting for the completion of corroborative tests or for the completion of long-time tests before rendering final reports. The intense commercial activity of the past year delayed these long-time tests to a considerable degree, since it was impossible to secure the immediate cooperation of a number of laboratories, which were later able to assist in the work. This late starting of the work necessarily delayed the final compilation of the data from all of the laboratories. Progress reports from each of the sub-committees will be submitted to Committee C-1 at the time of the annual meeting of the Society, and these will be used as a basis for outlining the work of the coming year.

The delay in securing the necessary data for the long-time tests prevents the committee from making any recommendations, other than requesting the continuance of the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars[1] as a revision of the Standard Specifications and Tests for Portland Cement. Sub-Committee VII on Strength has on hand all the data desired from three of the cooperating laboratories but is awaiting the data from three others. While it will all be on hand before the annual meeting, there will not be sufficient time for its digestion by the sub-committee and presentation with recommendations to Committee C-1. The committee therefore recommends that the present tentative revisions be continued. It might be added in this connection that although specific criticisms were requested in a note published with the tentative revisions, and discussion of these suggested specifications invited, yet none have so far been received by the secretary.

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[1] See pp. 630–633.—Ed.

The committee was also instructed to actively consider a revision of the specifications for natural cement. As a preliminary move to such a revision, the committee made three different canvasses of the manufacturers of this material, asking their criticisms of these present specifications and placing in their hands copies of these. Unfortunately, no satisfactory constructive criticism was received. One manufacturer asked to have a representative on the committee, another asked that the size of the containers be changed, and a third requested a lowering of the strength requirement. Either no replies or nothing definite was received from all the other manufacturers. On account of the delay in securing even this meager criticism from those most vitally interested in the material, the committee does not feel like making any immediate recommendations, but will further consider the matter during the coming year.

This report has been submitted to letter ballot of the committee, which consists of 54 members, of whom 45 have voted affirmatively, none negatively, and 9 have refrained from voting.

Respectfully submitted on behalf of the committee,

R. S. GREENMAN,
Chairman.

P. H. BATES,
Secretary.

EDITORIAL NOTE.

For Discussion on this report, see following page.

DISCUSSION.

Mr. Enright. MR. BERNARD ENRIGHT (*presented in written form and read by the Secretary*).—In connection with the subject matter of the report of Committee C-1 on Cement, there are a number of points which will bear careful consideration.

The indications are that there is approaching a world market, rather than a merely American market, for American cements. If different portions of the same sample of cement were sent to a half dozen different countries for careful analysis by a reputable chemist, the entire half dozen countries would report results practically conformable throughout. Chemical analysis, in other words, can be classed as an exact science.

Were the same portions sent to the same half-dozen countries for physical tests by equally reputable chemists or engineers to determine, say, the compressive strength, a half dozen sets of results varying probably widely from each other would be obtained. These results would differ, not only by the use of different apparatus and different methods of making the tests, and the difference in the "personal equation" of the operators, but also by reason of the fact that the same operator, in making retests by exactly the same method, seldom or never exactly duplicates his previous results, although he probably will, of course, obtain results sufficiently close to demonstrate the probable degree of accuracy of his conclusions.

Physical testing in other words is not, practically, an exact science. A great deal of painstaking care and consideration may be given to the question as to whether a cube or a cylinder, and what particular size of either, would make the most desirable form of test piece; at the same time it is a fact that an operator, using either the cube or the cylinder exclusively in one set of tests, may obtain a wider difference between these individual results than he would in a set of results in which both forms of test pieces were used. And he may obtain such results unconsciously, without any very perceptible change in manipulation.

Mr. Enright.

We naturally have no control whatever over the methods of making tests, or the specifications, of any foreign country. American cements are unexcelled any place in the world—it is even doubtful if any foreign cement equals them. At the same time, if we aim for export trade, it seems to me that we should not adopt any compressive strength specifications lower than those guaranteed by any foreign country; nor should we adopt, as standard, any method of making tests which, on the same sample of cement, would give materially lower strength results than would the standard methods of some foreign country, on the same sample of cement (again remembering that physical testing is not an exact science).

On the initial presentation of the Tentative Revisions of Standard Specifications and Tests for Portland Cement a year ago, I stated[1] that I had been making compressive strength tests for four years up to that time (this practice being of course still continued), and while it was naturally impracticable to attempt to quote all these figures, a general average of the 7-day and 28-day compressive strengths of 1 cement to 3 standard sand mortars, of both American cements and German cements, tested according to the German standard practice, was given. The American cements were shown to excel the German cements.

It is of interest to again note, and to draw attention to the fact, that for a great many years German cements have been guaranteed to show a compressive strength, at the 28-day period, on 1 cement to 3 standard sand mortars, as high as 3556 lb. per sq in., against the 2000 lb. per sq. in., for the same age and mortar, on American cements, shown in the present Tentative Revisions.

It would seem that the foreign consumer, who could not be expected to be familiar with the technology of cement testing, might be pardoned for drawing the conclusion that these figures meant that the German product was nearly twice as strong as the American cement. Presumably, of course, it might be explained to him that such figures only represented a different process of making tests, etc., that the American method was,

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I pp. 214–218.

Mr. Enright. scientifically, the more nearly perfect, and that the American cement was really, if anything, the superior of the two. Practically, it is a question how far such arguments would go with him.

Mr. Greenman. MR. R. S. GREENMAN (*Chairman of Committee C-1*).—Mr. Enright's discussion is just what the committee would like to have, criticisms and suggestions in regard to tentative specifications, and the chairman will gladly refer it to Sub-Committee VII on Strength.

I should like to state, in regard to the criticism of the 28-day specification, that the German standard sand is not our standard sand, and naturally different test results will be secured. I might state incidentally that The International Association for Testing Materials has a committee on Uniform Sand, but, as you know, that Association is not active at present. If, as Mr. Enright suggests, American cement becomes an item in the world market, then the consideration of a uniform world sand may be a practical and necessary problem.

REPORT OF COMMITTEE C-2
ON
REINFORCED CONCRETE.

Committee C-2 on Reinforced Concrete herewith submits the Final Report of the Joint Committee on Concrete and Reinforced Concrete, which is the result of the joint efforts of its own members and of the representatives of other societies appointed for the same purpose.

This report has been submitted to letter ballot of the committee, which consists of 12 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

F. E. Turneaure,
Chairman.

Richard L. Humphrey,
Secretary.

Editorial Note.

For action taken on this report see the Summary of Proceedings, pages 21-22.

For Discussion on the report, see page 263.

Final Report

OF THE

Joint Committee on Concrete and Reinforced Concrete

Preliminary Draft Prepared and Submitted by the Secretary, October 27, 1908
Amended and Adopted by Letter Ballot of the Committee, December 20, 1908
Revised and Brought Up to Date, November 20, 1912
Final Report Adopted by the Committee, July 1, 1916

AFFILIATED COMMITTEES

OF THE

American Society of Civil Engineers,
American Society for Testing Materials,
American Railway Engineering Association,
Portland Cement Association,
American Concrete Institute.

JULY 1, 1916

CONTENTS.

CHAPTER PAGE

I. INTRODUCTION........ 206

II. ADAPTABILITY OF CONCRETE AND REINFORCED CONCRETE........ 210

  1. Uses........ 210
  2. Precautions........ 210
  3. Design and Supervision........ 211
  4. Destructive Agencies........ 212
    - *a.* Corrosion of Metal Reinforcement.
    - *b.* Electrolysis.
    - *c.* Sea Water.
    - *d.* Acids.
    - *e.* Oils.
    - *f.* Alkalies.

III. MATERIALS........ 214

  1. Cement........ 214
    - *a.* Portland.
    - *b.* Natural.
    - *c.* Puzzolan or Slag.
    - *d.* Specifications.

  2. Aggregates........ 215
    - *a.* Fine Aggregate.
    - *b.* Coarse Aggregate.

  3. Water........ 217
  4. Metal Reinforcement........ 217

IV. MIXING AND PLACING........ 218

  1. Proportions........ 218
    - **a.** **Unit of Measure.**
    - **b.** **Relation of Fine and Coarse Aggregates.**
    - **c.** **Relation of Cement and Aggregates.**

CHAPTER PAGE

2. Mixing........ 219
   - *a.* Measuring Ingredients.
   - *b.* Machine Mixing.
   - *c.* Hand Mixing.
   - *d.* Consistency.
   - *e.* Retempering.

3. Placing........ 220
   - *a.* Methods.
   - *b.* Freezing Weather.
   - *c.* Rubble Concrete.
   - *d.* Under Water.

V. FORMS........ 222

VI. DETAILS OF CONSTRUCTION........ 223

1. Joints........ 223
   - *a.* In Concrete.
   - *b.* In Reinforcement.

2. Shrinkage and Temperature Changes........ 224
3. Fireproofing........ 225
4. Waterproofing........ 226
5. Surface Finish........ 227

VII. DESIGN........ 228

1. Massive Concrete........ 228
2. Reinforced Concrete........ 228
3. General Assumptions........ 228
   - *a.* Loads.
   - *b.* Lengths of Beams and Columns.
   - *c.* Stresses.

4. T-beams........ 230
5. Floor Slabs Supported Along Four Sides........ 231
6. Continuous Beams and Slabs........ 232
7. Bond Strength and Spacing of Reinforcement... 233
8. Diagonal Tension and Shear........ 234
9. Columns........ 238

CHAPTER PAGE
10. Reinforcing for Shrinkage and Temperature Stresses 241
11. Flat Slab.. 241
    a. Column Capital.
    b. Dropped Panel.
    c. Slab Thickness.
    d. Bending and Resisting Moments in Slabs.
    e. Names for Moment Sections.
    f. Positive Moment.
    g. Negative Moment.
    h. Moments for Oblong Panels.
    i. Wall Panels.
    j. Reinforcement.
    k. Point of Inflection.
    l. Arrangement of Reinforcement.
    m. Reinforcement at Construction Joints.
    n. Tensile and Compressive Stresses.
    o. Provision for Diagonal Tension and Shear.
    p. Walls and Openings.
    q. Unusual Panels.
    r. Bending Moments in Columns.

VIII. WORKING STRESSES.......................... 251
1. General Assumptions.......................... 251
2. Bearing.. 252
3. Axial Compression.......................... 252
4. Compression in Extreme Fiber.......................... 253
5. Shear and Diagonal Tension.......................... 253
6. Bond.. 254
7. Reinforcement.. 254
8. Modulus of Elasticity.......................... 255

IX. CONCLUSION.. 255

X. APPENDIX.. 257
Suggested Formulas for Reinforced Concrete Construction.......................... 257
1. Standard Notation.......................... 257
2. Formulas.. 258
    a. Rectangular Beams.
    b. T-Beams.
    c. Beams Reinforced for Compression.
    d. Shear, Bond, and Web Reinforcement.
    e. Columns.

CHAPTER I.

INTRODUCTION.

The Joint Committee on Concrete and Reinforced Concrete was formed by the union of Special Committees appointed in 1903 and 1904 by the American Society of Civil Engineers, the American Society for Testing Materials, the American Railway Engineering and Maintenance of Way Association (now the American Railway Engineering Association), and the Association of American Portland Cement Manufacturers (now the Portland Cement Association). In 1915 there was added a Special Committee appointed by the American Concrete Institute at the invitation of the Joint Committee.

The present organization and membership of the Joint Committee is as follows:

OFFICERS.

Chairman—Joseph R. Worcester.
Vice-Chairman—Emil Swensson.
Secretary—Richard L. Humphrey.

MEMBERS.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

John E. Greiner, Consulting Engineer, Baltimore, Md.

William K. Hatt, Professor of Civil Engineering, Purdue University, Lafayette, Ind.

Olaf Hoff, Consulting Engineer, 149 Broadway, New York, N. Y.

Richard L. Humphrey, Consulting Engineer, 805 Harrison Building, Philadelphia, Pa.

Robert W. Lesley, Past-President, Association of American Portland Cement Manufacturers, Pennsylvania Building, Philadelphia, Pa.

Emil Swensson, Consulting Engineer, 925 Frick Building, Pittsburgh, Pa.

Arthur N. Talbot, Professor of Municipal and Sanitary Engineering, University of Illinois, Urbana, Ill.

Joseph R. Worcester, Consulting Engineer, 79 Milk Street, Boston, Mass.

AMERICAN SOCIETY FOR TESTING MATERIALS.

William B. Fuller, Consulting Engineer, 150 Nassau Street, New York, N. Y.

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Progress reports by the Joint Committee were presented to the parent societies in 1909 and 1912. The report presented in 1912 has beeen printed by the American Society of Civil Engineers, the American Society for Testing Materials and the American Railway Engineering Association, and reference to that report may be made for details regarding the earlier work of the Joint Committee, a historical sketch of the introduction of concrete and reinforced concrete, and a bibliography of authorities upon which the report was based.

The Committee has been much gratified at the reception accorded its 1912 report, and realizes the responsibility which rests upon it because of the very extensive adoption of its recommendations in current practice in this country. The members of the Committee are well aware of the incompleteness of that report, and even now they are unable to pass judgment upon some matters not dealt with in the present report.

Since 1912 the Committee has continued its study of the subject, has followed the working out of its recommendations in actual construction, has weighed arguments and criticisms which have come to its attention, and has considered new experimental data. While the Committee sees no reason for making any fundamental changes, the recommendations of its previous report have been revised to some extent, and considerable new material has been added upon subjects not previously touched. There are some subjects upon which experimentation is still in progress, and the art of concrete and reinforced concrete will be advancing for many years to come.

While this report deals with every kind of stress to which concrete is subjected and includes all ordinary conditions of proportioning and handling, it does not go into all types of construction nor all the applications to which concrete and reinforced concrete may be put. The report is not a specification but may be used as a basis for specifications. In their use concrete and reinforced concrete involve the exercise of good judgment to a greater degree than do any other building materials. Rules cannot produce or supersede judgment; on the contrary, judgment should control the interpretation and application of rules.

The Committee has not attempted in every case to present rigidly scientific methods of analysis in dealing with stresses, but has aimed to furnish rules which will lead to safe results sufficiently close for ordinary design.

The Committee presumes that the application of the recommendations in this report to the design of any structure will be made only by persons having an adequate knowledge of the principles of structural design. Only persons with such knowledge and experience should be called upon to design reinforced concrete structures.

The Joint Committee has reached the conclusion that, with this effort to express the present state of the art, it would be desirable for it to withdraw from the field. This action has been taken in the hope that a work similar to that which the Committee has attempted to perform will again be undertaken, within a reasonable term of years, in order that there may be some authoritative body to consider and pass upon newly acquired knowledge and information gleaned from experience. The Committee feels certain, however, that it would be for the better interest of the profession to entrust this work to other hands rather than to continue the present organization with this object in view.

CHAPTER II.

ADAPTABILITY OF CONCRETE AND REINFORCED CONCRETE.

The adaptability of concrete and reinforced concrete for engineering structures or parts thereof, is so well established that they are recognized materials of construction. When properly used, they have proved satisfactory for those purposes for which their qualities make them particularly suitable.

1. USES.

Plain concrete is well adapted for structures in which the principal stresses are compressive, such as:—foundations, dams, retaining and other walls, tunnels, piers, abutments, and, in many cases, arches.

By the use of metal reinforcement to resist the principal tensile stresses, concrete becomes available for general use in various structures and structural forms. This combination of concrete and metal is particularly advantageous in structural members subject to both compression and tension, and in columns where, although the main stresses are compressive, there is also cross-bending.

Metal reinforcement may also be used to advantage to distribute and minimize cracks due to shrinkage and temperature changes.

2. PRECAUTIONS.

Failures of reinforced concrete structures have been due usually to some one or more of the following causes:

Defective design, poor material, faulty execution, or premature removal of forms.

To prevent failures or otherwise unsatisfactory results, the following precautions should be taken:

The computations and assumptions on which the design is based should be in accordance with the established principles of mechanics. The unit stresses and details of the design should conform to accepted good practice. Materials used for the concrete as well as for the reinforcement should be carefully inspected and tested, special attention being given to the testing of the sand, as poor sand has proved a frequent cause of failure. The measuring and combining of the materials which go to make up the concrete, and the placing of the concrete in the forms, should be under the supervision of experienced men. The metal for reinforcement should be of a quality conforming to standard specifications. Care should be taken to obtain good bond between different fills of concrete, to prevent concrete from freezing before the cement has set, to have the materials thoroughly mixed, to avoid too wet or too dry a consistency, and to have the forms cleaned before concrete is placed.

The computations should include all details; even minor details may be of the utmost importance. The design should show clearly the size and position of the reinforcement, and should provide for proper connection between the component parts so that they cannot be displaced. As the connections between reinforced concrete members are frequently a source of weakness, the design should include a detailed study of such connections.

The concrete should be rigidly supported until it has developed sufficient strength to carry imposed loads. The most careful and experienced inspection is necessary to determine when the concrete has set sufficiently for it to be safe to remove forms. Frozen concrete frequently has been mistaken for properly set concrete.

3. DESIGN AND SUPERVISION.

The execution of the work should not be separated from the design, as intelligent supervision and successful execution can be expected only when both functions are combined. It is desirable, therefore, that the engineer who prepares the design and specifications should have supervision of the execution of the work.

The Committee recommends the following practice for the purpose of fixing the responsibility and providing for adequate supervision during construction:

(*a*) Before work is commenced, complete plans and specifications should be prepared, giving the dead and live loads, wind and impact, if any, and working stresses, showing the general arrangement and all details. The plans should show the size, length, location of points of bending, and exact position of all reinforcement, including stirrups, ties, hooping and splicing.

(*b*) The specifications should state the qualities of the materials and the proportions in which they are to be used.

(*c*) The strength which the concrete is expected to attain after a definite period should be stated in the specifications.

(*d*) Inspection during construction should be made by competent inspectors selected by and under the supervision of the engineer, and should cover the following:

1. Materials.
2. Construction and erection of the forms and supports.
3. Sizes, shapes, arrangement, position and fastening of the reinforcement.
4. Proportioning, mixing, consistency, and placing of the concrete.
5. Strength of the concrete by tests of standard test pieces made on the work.
6. Whether the concrete is sufficiently hardened before the forms and supports are removed.
7. Protection from injury of all parts of the structure.
8. Comparison of dimensions of all parts of the finished structure with the plans.

(*e*) Load tests on portions of the finished structure should be made where there is reasonable suspicion that the work has not been properly performed, or that, through influences of some kind, the strength has been impaired, or where there is any doubt as to the sufficiency of the design. The loading should be carried to such a point that the calculated stresses under such loading shall be one and three-quarters times the allowed working stresses, and such loads should cause no injurious permanent deformations. Load tests should not be made before the concrete has been in place sixty days.

4. DESTRUCTIVE AGENCIES.

(*a*) *Corrosion of Metal Reinforcement.*—Tests and experience indicate that steel sufficiently embedded in good concrete is well protected against corrosion, no matter whether located above or below water level. It is recommended that such protection be not less than 1 in. in thickness. If the concrete is porous so as to be readily permeable by water, as when the concrete is laid with a very dry consistency, the metal may corrode on account of the presence of moisture and air.

(*b*) *Electrolysis.*—The experimental data available on this subject seem to show that while reinforced concrete structures may, under certain conditions, be injured by the flow of electric current in either direction between the reinforcing material and the concrete, such injury is generally to be expected only where voltages are considerably higher than those which usually occur in concrete structures in practice. If the iron be positive, trouble may manifest itself by corrosion of the iron accompanied by cracking of the concrete, and, if the iron be negative, there may be a softening of the concrete near the surface of the iron, resulting in a destruction of the bond. The former, or anode effect, decreases much more rapidly than the voltage, and almost if not quite disappears at voltages that are most likely to be encountered in practice. The cathode effect, on the other hand, takes place even under very low voltages, and is therefore more important from a practical standpoint than that of the anode.

Structures containing salt or calcium chloride, even in very small quantities, are very much more susceptible to the effects of electric currents than normal concrete, the anode effect progressing much more rapidly in the presence of chlorine, and the cathode effect being greatly increased by the presence of an alkali metal.

There is great weight of evidence to show that normal reinforced concrete structures free from salt are in very little danger under most practical conditions, while non-reinforced concrete structures are practically immune from electrolysis troubles.

(*c*) *Sea Water.*—The data available concerning the effect of sea water on concrete or reinforced concrete are limited and inconclusive. Sea walls out of the range of frost action have been standing for many years without apparent injury. In many places serious disintegration has taken place. This has occurred chiefly between low and high tide levels and is due, evidently, in part to frost. Chemical action also appears to be indicated by the softening of the mortar. To effect the best resistance to sea water, the concrete must be proportioned, mixed and placed so as to prevent the penetration of sea water into the mass or through the joints. The aggregates should be carefully selected, graded and proportioned with the cement so as to secure the maximum possible density; the concrete should be thoroughly mixed; the joints between old and new work should be made watertight; and the concrete should be kept from exposure to sea water until it is thoroughly hard and impervious.

(*d*) *Acids.*—Dense concrete thoroughly hardened is affected appreciably only by acids which seriously injure other materials. Substances like manure that contain acids may injuriously affect green concrete, but do not affect concrete that is thoroughly hardened.

(*e*) *Oils.*—Concrete is unaffected by such mineral oils as petroleum and ordinary engine oils. Oils which contain fatty acids produce injurious effects, forming compounds with the lime which may result in a disintegration of the concrete in contact with them.

(*f*) *Alkalies.*—The action of alkalies on concrete is problematical. In the reclamation of arid land where the soil is heavily charged with alkaline salts it has been found that concrete, stone, brick, iron and other materials are injured under certain conditions. It would seem that at the level of the ground water in an extremely dry atmosphere such structures are disintegrated, through the rapid crystallization of the alkaline salts, resulting from the alternate wetting and drying of the surface. Such destructive action can be prevented by the use of a protective coating and is minimized by securing a dense concrete.

CHAPTER III.

MATERIALS.

The quality of all the materials is of paramount importance. The cement and also the aggregates should be subject to definite requirements and tests.

1. CEMENT.

There are available for construction purposes Portland, Natural and Puzzolan or Slag cements.

(*a*) *Portland Cement* is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion, an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

It has a definite chemical composition varying within comparatively narrow limits.

Portland cement only should be used in reinforced concrete construction or in any construction that will be subject to shocks, vibrations, or stresses other than direct compression.

(*b*) *Natural Cement* is the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Although the limestone must have a certain composition, this composition may vary within much wider limits than in the case of Portland cement. Natural cement does not develop its strength as quickly nor is it as uniform in composition as Portland cement.

Natural cement may be used in massive masonry where weight rather than strength is the essential feature.

Where economy is the governing factor a comparison may be made between the use of natural cement and a leaner mixture of Portland cement that will develop the same strength.

(*c*) *Puzzolan or Slag Cement* is the product resulting from finely pulverizing a mechanical mixture of granulated basic blast-furnace slag and hydrated lime.

Puzzolan cement is not nearly as strong, uniform, or reliable as Portland or natural cement, is not used extensively, and never in important work; it should be used only for unimportant foundation work underground where it is not exposed to air or running water.

(*d*) *Specifications.*—The cement should meet the requirements of the specifications and methods of tests for Portland cement, which are the result of the joint labors of special committees of the American Society of Civil Engineers, American Society for Testing Materials, American Railway Engineering Association, and other affiliated organizations, and the United States Government.

2. AGGREGATES.

Extreme care should be exercised in selecting the aggregates for mortar and concrete, and careful tests made of the materials for the purpose of determining the quality and grading necessary to secure maximum density[1] or a minimum percentage of voids. Bank gravel should be separated by screening into fine and coarse aggregates and then used in the proportions to be determined by density tests.

(*a*) *Fine Aggregate* should consist of sand, or the screenings of gravel or crushed stone, graded from fine to coarse, and passing when dry a screen having ¼-in. diameter holes;[2] it preferably should be of siliceous material, and not more than 30 per cent by weight, should pass a sieve having 50 meshes per linear inch; it should be clean, and free from soft particles, lumps of clay, vegetable loam or other organic matter.

Fine aggregate should always be tested for strength. It should be of such quality that mortar composed of one part Portland cement and three parts fine aggregate by weight when made into briquettes, prisms or cylinders will show a tensile or compressive strength, at an age of not less than 7 days, at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand.[3] If the aggregate be of poorer quality, the proportion of cement should be increased to secure the desired strength. If the strength developed by the aggregate in the 1:3 mortar is less than 70 per cent of the strength of the Ottawa-sand mortar, the material should be rejected. In testing aggregates care should be exercised to avoid the removal of any coating on the grains, which may affect the strength; bank sands should not be dried before being made into mortar, but should contain natural moisture. The percentage of moisture may be determined upon a separate sample for correcting weight. From 10 to 40 per cent more water may be required in mixing bank or artificial sands than for standard Ottawa sand to produce the same consistency.

(*b*) *Coarse Aggregate* should consist of gravel or crushed stone which is retained on a screen having ¼-in. diameter holes, and should be graded from the smallest to the largest particles; it should be clean, hard, durable, and free from all deleterious matter. Aggregates containing dust and soft, flat or elongated particles, should be excluded. The Committee does not feel warranted in recommending the use of blast furnace slag as an aggregate, in the absence of adequate data as to its value, especially in reinforced concrete construction. No satisfactory specifications or methods of inspection have been developed that will control its uniformity and ensure the durability of the concrete in which it is used.

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[1] A convenient coefficient of density is the ratio of the sum of the volumes of solid particles contained in a unit volume to the total unit volume.

[2] If the dividing size between the fine and coarse aggregate is less or greater than one-quarter inch, allowance should be made in grading and proportioning.

[3] A natural sand obtained at Ottawa, Illinois, passing a screen having 20 meshes and retained on a screen having 30 meshes per linear inch; prepared and furnished by the Ottawa Silica Company, for 2 cents per pound f. o. b. cars, Ottawa, Illinois.

The aggregate must be small enough to produce with the mortar a homogeneous concrete of sluggish consistency which will pass readily between and easily surround the reinforcement and fill all parts of the forms. The maximum size of particles is variously determined for different types of construction from that which will pass a ½-in. ring to that which will pass a 1½-in. ring.

For concrete in large masses the size of the coarse aggregate may be increased, as a large aggregate produces a stronger concrete than a fine one; however it should be noted that the danger of separation from the mortar becomes greater as the size of the coarse aggregate increases.

Cinder concrete should not be used for reinforced concrete structures except in floor slabs not exceeding 8-ft. span. It also may be used for fire protection purposes where not required to carry loads. The cinders used should be composed of hard, clean, vitreous clinker, free from sulphides, unburned coal or ashes.

3. WATER.

The water used in mixing concrete should be free from oil, acid, alkali, or organic matter.

4. METAL REINFORCEMENT.

The Committee recommends as a suitable material for reinforcement, steel of structural grade filling the requirements of the Specifications for Billet-Steel Concrete Reinforcement Bars of the American Society for Testing Materials.

For reinforcing slabs, small beams or minor details, or for reinforcing for shrinkage and temperature stresses, steel wire, expanded metal, or other reticulated steel may be used, with the unit stresses hereinafter recommended.

The reinforcement should be free from flaking rust, scale, or coatings of any character which would tend to reduce or destroy the bond.

CHAPTER IV.

MIXING AND PLACING.

1. PROPORTIONS.

The materials should be carefully selected, of uniform quality, and proportioned with a view to securing as nearly as possible a maximum density, which is obtained by grading the aggregates so that the smaller particles fill the spaces between the larger thus reducing the voids in the aggregate to the minimum.

(*a*) *Unit of Measure.*—The measurement of the fine and coarse aggregates should be by loose volume. The unit of measure should be a bag of cement, containing 94 lb. net, which should be considered the equivalent of one cubic foot.

(*b*) *Relation of Fine and Coarse Aggregates.*—The fine and coarse aggregates should be used in such proportions as will secure maximum density. These proportions should be carefully determined by density experiments and the grading of the fine and coarse aggregates should be uniformly maintained, or the proportions changed to meet the varying sizes.

(*c*) *Relation of Cement and Aggregates.*—For reinforced concrete construction, one part of cement to a total of six parts of fine and coarse aggregates measured separately should generally be used. For columns, richer mixtures are preferable. In massive masonry or rubble concrete a mixture of 1 : 9 or even 1 : 12 may be used.

These proportions should be determined by the strength or other qualities required in the construction at the critical period of use. Experience and judgment based on observation and tests of similar conditions in similar localities are excellent guides as to the proper proportions for any particular case.

In important construction, advance tests should be made on concrete composed of the materials to be used in the work.

These tests should be made by standardized methods to obtain uniformity in mixing, proportioning and storage, and in case the results do not conform to the requirements of the work, aggregates of a better quality or more cement should be used to obtain the desired quality of concrete.

2. MIXING.

The mixing of concrete should be thorough, and continue until the mass is uniform in color and homogeneous. As the maximum density and greatest strength of a given mixture depend largely on thorough and complete mixing, it is essential that this part of the work should receive special attention and care.

Inasmuch as it is difficult to determine, by visual inspection, whether the concrete is uniformly mixed, especially where aggregates having the color of cement are used, it is essential that the mixing should occupy a definite period of time. The minimum time will depend on whether the mixing is done by machine or hand.

(*a*) *Measuring Ingredients.*—Methods of measurement of the various ingredients should be used which will secure at all times separate and uniform measurements of cement, fine aggregate, coarse aggregate, and water.

(*b*) *Machine Mixing.*—The mixing should be done in a batch machine mixer of a type which will ensure the uniform distribution of the materials throughout the mass, and should continue for the minimum time of one and one-half minutes after all the ingredients are assembled in the mixer. For mixers of two or more cubic yards capacity, the minimum time of mixing should be two minutes. Since the strength of the concrete is dependent upon thorough mixing, a longer time than this minimum is preferable. It is desirable to have the mixer equipped with an attachment for automatically locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required after they are assembled in the mixer. Means should be provided to prevent aggregates being added after the mixing has commenced. The mixer should also be equipped with water storage, and an automatic measuring device which can be locked is desirable. It is also desirable to equip the mixer with a device recording the revolutions of the drum. The number of revolutions should be so regulated as to give at the periphery of the drum a uniform speed; about 200 ft. per minute seems to be the best speed in the present state of the art.

(*c*) *Hand Mixing.*—Hand mixing should be done on a watertight platform and especial precautions taken after the water has been added, to turn all the ingredients together at least six times, and until the mass is homogeneous in appearance and color.

(*d*) *Consistency.*—The materials should be mixed wet enough to produce a concrete of such a consistency as will flow sluggishly into the forms and about the metal reinforcement when used, and which, at the same time, can be conveyed from the mixer to the forms without separation of the coarse aggregate from the mortar. The quantity of water is of the greatest importance in securing concrete of maximum strength and density; too much water is as objectionable as too little.

(*e*) *Retempering.*—The remixing of mortar or concrete that has partly set should not be permitted.

3. PLACING CONCRETE.

(*a*) *Methods.*—Concrete after the completion of the mixing should be conveyed rapidly to the place of final deposit; under no circumstances should concrete be used that has partly set.

Concrete should be deposited in such a manner as will permit the most thorough compacting, such as can be obtained by working with a straight shovel or slicing tool kept moving up and down until all the ingredients are in their proper place. Special care should be exercised to prevent the formation of laitance; where laitance has formed it should be removed, since it lacks strength, and prevents a proper bond in the concrete.

Before depositing concrete, the reinforcement should be carefully placed in accordance with the plans. It is essential that adequate means be provided to hold it in its proper position until the concrete has been deposited and compacted; care should be taken that the forms are substantial and thoroughly wetted (except in freezing weather) or oiled and that the space to be occupied by the concrete is free from débris. When the placing of concrete is suspended, all necessary grooves for joining future work should be made before the concrete has set.

When work is resumed, concrete previously placed should be roughened, cleansed of foreign material and laitance, thoroughly wetted and then slushed with a mortar consisting of one part Portland cement and not more than two parts fine aggregate.

The surfaces of concrete exposed to premature drying should be kept covered and wet for a period of at least seven days.

Where concrete is conveyed by spouting, the plant should be of such a size and design as to ensure a practically continuous stream in the spout. The angle of the spout with the horizontal should be such as to allow the concrete to flow without a separation of the ingredients; in general an angle of about 27 deg. or one vertical to two horizontal is good practice. The spout should be thoroughly flushed with water before and after each run. The delivery from the spout should be as close as possible to the point of deposit. Where the discharge must be intermittent, a hopper should be provided at the bottom. Spouting through a vertical pipe is satisfactory when the flow is continuous; when it is unchecked and discontinuous it is highly objectionable unless the flow is checked by baffle plates.

(*b*) *Freezing Weather.*—Concrete should not be mixed or deposited at a freezing temperature, unless special precautions are taken to prevent the use of materials covered with ice crystals or containing frost, and to prevent the concrete from freezing before it has set and sufficiently hardened.

As the coarse aggregate forms the greater portion of the concrete, it is particularly important that this material be warmed to well above the freezing point.

The enclosing of a structure and the warming of the space inside the enclosure is recommended, but the use of salt to lower the freezing point is not recommended.

(*c*) *Rubble Concrete.*—Where the concrete is to be deposited in massive work, its value may be improved and its cost materially reduced by the use of clean stones, saturated with water, thoroughly embedded in and entirely surrounded by concrete.

(*d*) *Under Water.*—In placing concrete under water it is essential to maintain still water at the place of deposit. With careful inspection the use of tremies, properly designed and operated, is a satisfactory method of placing concrete through water. The concrete should be mixed very wet (more so than is ordinarily permissible) so that it will flow readily through the tremie and into place with practically a level surface.

The coarse aggregate should be smaller than ordinarily used, and never more than 1 in. in diameter. The use of gravel facilitates mixing and assists the flow. The mouth of the tremie should be buried in the concrete so that it is at all times entirely sealed and the surrounding water prevented from forcing itself into the tremie; the concrete will then discharge without coming in contact with the water. The tremie should be suspended so that it can be lowered quickly when it is necessary either to choke off or prevent too rapid flow; the lateral flow preferably should be not over 15 ft.

The flow should be continuous in order to produce a monolithic mass and to prevent the formation of laitance in the interior. In case the flow is interrupted it is important that all laitance be removed before proceeding with the work.

In large structures it may be necessary to divide the mass of concrete into several small compartments or units, to permit the continuous filling of each one. With proper care it is possible in this manner to obtain as good results under water as in the air.

A less desirable method is the use of the drop bottom bucket. Where this method is used, the bottom of the bucket should be released when in contact with the surface of the place of deposit.

CHAPTER V.

FORMS.

Forms should be substantial and unyielding, in order that the concrete may conform to the design, and be sufficiently tight to prevent the leakage of mortar.

It is vitally important to allow sufficient time for the proper hardening of the concrete, which should be determined by careful inspection before the forms are removed.

Many conditions affect the hardening of concrete, and the proper time for the removal of the forms should be determined by some competent and responsible person.

It may be stated in a general way that forms should remain in place longer for reinforced concrete than is required for plain or massive concrete, and longer for horizontal than is required for vertical members.

In general it may be considered that concrete has hardened sufficiently when it has a distinctive ring under the blow of a hammer, but this test is not reliable, if there is a possibility that the concrete is frozen.

CHAPTER VI.

DETAILS OF CONSTRUCTION.

1. JOINTS.

(*a*) *In Concrete.*—It is desirable to cast an entire structure at one operation, but as this is not always possible, especially in large structures, it is necessary to stop the work at some convenient point. This should be selected so that the resulting joint may have the least possible effect on the strength of the structure. It is therefore recommended that the joint in columns be made flush with the lower side of the girders, or in flat slab construction at the bottom of the flare of the column head; that the joints in girders be at a point midway between supports, unless a beam intersect a girder at this point, in which case the joint should be offset a distance equal to twice the width of the beam; and that the joints in the members of a floor system should in general be made at or near the center of the span.

Joints in columns should be perpendicular to the axis, and in girders, beams, and floor slabs, perpendicular to the plane of their surfaces. When it is necessary to provide for shear at right angles to the axis, it is permissible to incline the plane of the joint as much as 30 deg. from the perpendicular. Joints in arch rings should be on planes as nearly radial as practicable.

Before placing the concrete on top of a freshly poured column a period of at least two hours should be allowed for the settlement and shrinkage.

Shrinkage and contraction joints may be necessary to concentrate cracks due to temperature in smooth even lines. The number of these joints which should be determined and provided for in the design will depend on the range of temperature to which the concrete will be subjected, and on the amount and position of the reinforcement. In massive work, such as retaining walls, abutments, etc., built without reinforcement, contraction joints should be provided, at intervals of from 25 to 50 ft. and with reinforcement from 50 to 80 ft.; the smaller the height and thickness, the closer the spacing. The joints should be tongued and grooved to maintain the alignment in case of unequal settlement. A groove may be formed in the surface as a finish to vertical joints.

Shrinkage and contraction joints should be lubricated by an application of petroleum oil or a similar material to permit a free movement when the concrete expands or contracts.

The movement of the joint due to expansion and contraction may be facilitated by the insertion of a sheet of copper, zinc, or even tarred paper.

(*b*) *In Reinforcement.*—Wherever it is necessary to splice tension reinforcement the length of lap should be determined on the basis of the safe bond stress, the stress in the bar and the shearing resistance of the concrete at the point of splice; or a connection should be made between the bars of sufficient strength to carry the stress. Splices at points of maximum stress in tension should be avoided. In columns, bars more than $\frac{3}{4}$ in. in diameter not subject to tension should have their ends properly squared and butted together in suitable sleeves; smaller bars may be lapped as indicated for tension reinforcement. At foundations bearing plates should be provided for supporting the bars, or the bars may be carried into the footing a sufficient distance to transmit the stress in the steel to the concrete by means of the bearing and the bond resistance. In no case should reliance be placed upon the end bearing of bars on concrete.

2. SHRINKAGE AND TEMPERATURE CHANGES.

The stresses resulting from shrinkage due to hardening and contraction from temperature changes are important in monolithic construction, and unless cared for in the design will produce objectionable cracks; cracks cannot be entirely prevented but the effects can be minimized.

Large cracks, produced by quick hardening or wide ranges of temperature, can be broken up to some extent into small cracks by placing reinforcement in the concrete; in long, continuous lengths of concrete, it is better to provide shrinkage joints at points in the structure where they will do little or no harm. Reinforcement permits longer distances between shrinkage joints than when no reinforcement is used.

Provision for shrinkage should be made where small or thin masses are joined to larger or thicker masses; at such places the use of fillets similar to those used in metal castings, but proportionally larger, is recommended.

Shrinkage cracks are likely to occur at points where fresh concrete is joined to that which is set, and hence in placing the concrete, construction joints should be made, as described in Chapter VI, Sect. 1, or if possible, at points where joints would naturally occur in dimension stone masonry.

3. FIREPROOFING.

Concrete, because incombustible and of a low rate of heat conductivity, is highly efficient and admirably adapted for fireproofing purposes. This has been demonstrated by experience and tests.

The dehydration of concrete probably begins at about 500° F. and is completed at about 900° F., but experience indicates that the volatilization of the water absorbs heat from the surrounding mass, which, together with the resistance of the air cells, tends to increase the heat resistance of the concrete, so that the process of dehydration is very much retarded. The concrete that is actually affected by fire and remains in position affords protection to that beneath it.

The thickness of the protective coating should be governed by the intensity and duration of a possible fire and the rate of heat conductivity of the concrete. The question of the rate of heat conductivity of concrete is one which requires further study and investigation before a definite rate for different classes of concrete can be fully established. However, for ordinary conditions it is recommended that the metal be protected by a minimum of 2 in. of concrete on girders and columns, $1\frac{1}{2}$ in. on beams, and 1 in. on floor slabs.

Where fireproofing is required and not otherwise provided in monolithic concrete columns, it is recommended that the concrete to a depth of 1½ in. be considered as protective covering and not included in the effective section.

The corners of columns, girders, and beams should be beveled or rounded, as a sharp corner is more seriously affected by fire than a round one; experience shows that round columns are more fire resistive than square.

4. WATERPROOFING.

Many expedients have been resorted to for rendering concrete impervious to water. Experience shows, however, that when mortar or concrete is proportioned to obtain the greatest practicable density and is mixed to the proper consistency (Chap. IV, Sect. 2 *d*), the resulting mortar or concrete is impervious under moderate pressure.

On the other hand, concrete of dry consistency is more or less pervious to water, and, though compounds of various kinds have been mixed with the concrete or applied as a wash to the surface, in an effort to offset this defect, these expedients have generally been disappointing, for the reason that many of these compounds have at best but temporary value, and in time lose their power of imparting impermeability to the concrete.

In the case of subways, long retaining walls and reservoirs, provided the concrete itself is impervious, cracks may be so reduced by horizontal and vertical reinforcement properly proportioned and located, that they will be too minute to permit leakage, or will be closed by infiltration of silt.

Asphaltic or coal-tar preparations applied either as a mastic or as a coating on felt or cloth fabric, are used for waterproofing, and should be proof against injury by liquids or gases.

For retaining and similar walls in direct contact with the earth, the application of one or two coatings of hot coal-tar pitch, following a painting with a thin wash of coal tar dissolved in benzol, to the thoroughly dried surface of concrete is an efficient method of preventing the penetration of moisture from the earth.

5. SURFACE FINISH.

Concrete is a material of an individual type and should be used without effort at imitation of other building materials. One of the important problems connected with its use is the character of the finish of exposed surfaces. The desired finish should be determined before the concrete is placed, and the work conducted so as to facilitate securing it. The natural surface of the concrete in most structures is unobjectionable, but in others the marks of the forms and the flat dead surface are displeasing, making some special treatment desirable. A treatment of the surface which removes the film of cement and brings the aggregates of the concrete into relief, either by scrubbing with brushes and water before it is hard or by tooling it after it is hard, is frequently used to erase the form markings and break the monotonous appearance of the surface. Besides being more pleasing in immediate appearance such a surface is less subject to discoloration and hair cracking than is a surface composed of the cement that segregates against the forms, or one that is made by applying a cement wash. The aggregates can also be exposed by washing with hydrochloric acid diluted with from 6 to 10 parts of water. The plastering of surfaces should be avoided, for even if carefully done, it is liable to peel off under the action of frost or temperature changes.

Various effects in texture and in color can be obtained when the surface is to be scrubbed or tooled, by using aggregates of the desired size and color. For a fine grained texture a granolithic surface mixture can be made and placed against the face forms to a thickness of about 1 in. as the placing of the body of the concrete proceeds.

A smooth, even surface without form marks can be secured by the use of plastered forms, which in structures having many duplications of members can be used repeatedly; these are made in panels of expanded metal or wire mesh coated with plaster, and the joints made at edges, and closed with plaster of Paris.

CHAPTER VII.

DESIGN.

1. MASSIVE CONCRETE.

In the design of massive or plain concrete, no account should be taken of the tensile strength of the material, and sections should usually be proportioned so as to avoid tensile stresses except in slight amounts to resist indirect stresses. This will generally be accomplished in the case of rectangular shapes if the line of pressure is kept within the middle third of the section, but in very large structures, such as high masonry dams, a more exact analysis may be required. Structures of massive concrete are able to resist unbalanced lateral forces by reason of their weight; hence the element of weight rather than strength often determines the design. A leaner and relatively cheap concrete, therefore, will often be suitable for massive concrete structures.

It is desirable generally to provide joints at intervals to localize the effect of contraction (Chap. VI, Sect. 1).

Massive concrete is suitable for dams, retaining walls, and piers in which the ratio of length to least width is relatively small. Under ordinary conditions this ratio should not exceed four. It is also suitable for arches of moderate span.

2. REINFORCED CONCRETE.

The use of metal reinforcement is particularly advantageous in members such as beams in which both tension and compression exist, and in columns where the principal stresses are compressive and where there also may be cross-bending. Therefore the theory of design here presented relates mainly to the analysis of beams and columns.

3. GENERAL ASSUMPTIONS.

(*a*) *Loads.*—The forces to be resisted are those due to:

1. *The dead load,* which includes the weight of the structure and fixed loads and forces.

2. *The live load*, or the loads and forces which are variable. The dynamic effect of the live load will often require consideration. Allowance for the latter is preferably made by a proportionate increase in either the live load or the live load stresses. The working stresses hereinafter recommended are intended to apply to the equivalent static stresses thus determined.

   In the case of high buildings the live load on columns may be reduced in accordance with the usual practice.

(*b*) *Lengths of Beams and Columns.*—The span length for beams and slabs simply supported should be taken as the distance from center to center of supports, but need not be taken to exceed the clear span plus the depth of beam or slab. For continuous or restrained beams built monolithically into supports the span length may be taken as the clear distance between faces of supports. Brackets should not be considered as reducing the clear span in the sense here intended, except that when brackets which make an angle of 45 deg. or more with the axis of a restrained beam are built monolithically with the beam, the span may be measured from the section where the combined depth of beam and bracket is at least one-third more than the depth of the beam. Maximum negative moments are to be considered as existing at the end of the span as here defined.

When the depth of a restrained beam is greater at its ends than at midspan and the slope of the bottom of the beam at its ends makes an angle of not more than 15 deg. with the direction of the axis of the beam at midspan, the span length may be measured from face to face of supports.

The length of columns should be taken as the maximum unstayed length.

(*c*) *Stresses.*—The following assumptions are recommended as a basis for calculations:

1. Calculations will be made with reference to working stresses and safe loads rather than with reference to ultimate strength and ultimate loads.
2. A plane section before bending remains plane after bending.

3. The modulus of elasticity of concrete in compression is constant within the usual limits of working stresses. The distribution of compressive stress in beams is therefore rectilinear.
4. In calculating the moment of resistance of beams the tensile stresses in the concrete are neglected.
5. The adhesion between the concrete and the reinforcement is perfect. Under compressive stress the two materials are therefore stressed in proportion to their moduli of elasticity.
6. The ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete is taken at 15 except as modified in Chapter VIII, Section 8.
7. Initial stress in the reinforcement due to contraction or expansion of the concrete is neglected.

It is recognized that some of the assumptions given herein are not entirely borne out by experimental data. They are given in the interest of simplicity and uniformity, and variations from exact conditions are taken into account in the selection of formulas and working stresses.

The deflection of a beam depends upon the strength and stiffness developed throughout its length. For calculating deflection a value of 8 for the ratio of the moduli will give results corresponding approximately with the actual conditions.

4. T-BEAMS.

In beam and slab construction an effective bond should be provided at the junction of the beam and slab. When the principal slab reinforcement is parallel to the beam, transverse reinforcement should be used extending over the beam and well into the slab.

The slab may be considered an integral part of the beam, when adequate bond and shearing resistance between slab and web of beam is provided, but its effective width shall be determined by the following rules:

(*a*) It shall not exceed one-fourth of the span length of the beam;

(*b*) Its overhanging width on either side of the web shall not exceed six times the thickness of the slab.

In the design of continuous T-beams, due consideration should be given to the compressive stress at the support.

Beams in which the T-form is used only for the purpose of providing additional compression area of concrete should preferably have a width of flange not more than three times the width of the stem and a thickness of flange not less than one-third of the depth of the beam. Both in this form and in the beam and slab form the web stresses and the limitations in placing and spacing the longitudinal reinforcement will probably be controlling factors in design.

5. FLOOR SLABS SUPPORTED ALONG FOUR SIDES.

Floor slabs having the supports extending along the four sides should be designed and reinforced as continuous over the supports. If the length of the slab exceeds 1.5 times its width the entire load should be carried by transverse reinforcement.

For uniformly distributed loads on square slabs, one-half the live and dead load may be used in the calculations of moment to be resisted in each direction. For oblong slabs, the length of which is not greater than one and one-half times their width, the moment to be resisted by the transverse reinforcement may be found by using a proportion of the live and dead load equal to that given by the formula $r=\frac{l}{b}-0.5$, where l=length and b=breadth of slab. The longitudinal reinforcement should then be proportioned to carry the remainder of the load.

In placing reinforcement in such slabs account may well be taken of the fact that the bending moment is greater near the center of the slab than near the edges. For this purpose two-thirds of the previously calculated moments may be assumed as carried by the center half of the slab and one-third by the outside quarters.

Loads carried to beams by slabs which are reinforced in two directions will not be uniformly distributed to the supporting beams and the distribution will depend on the relative stiffness of the slab and the supporting beams. The distribution which may be expected ordinarily is a variation of the load in the beam in accordance with the ordinates of a parabola, having its vertex at the middle of the span. For any given design, the probable distribution should be ascertained and the moments in the beam calculated accordingly.

6. CONTINUOUS BEAMS AND SLABS.

When the beam or slab is continuous over its supports, reinforcement should be fully provided at points of negative moment, and the stresses in concrete recommended in Chapter VIII, Section 4, should not be exceeded. In computing the positive and negative moments in beams and slabs continuous over several supports, due to uniformly distributed loads, the following rules are recommended:

(*a*) For floor slabs the bending moments at center and at support should be taken at $\frac{wl^2}{12}$ for both dead and live loads, where w represents the load per linear unit and l the span length.

(*b*) For beams the bending moment at center and at support for interior spans should be taken at $\frac{wl^2}{12}$, and for end spans it should be taken at $\frac{wl^2}{10}$ for center and interior support, for both dead and live loads.

(*c*) In the case of beams and slabs continuous for two spans only, with their ends restrained, the bending moment both at the central support and near the middle of the span should be taken at $\frac{wl^2}{10}$.

(*d*) At the ends of continuous beams the amount of negative moment which will be developed in the beam will depend on the condition of restraint or fixedness, and this will depend on the form of construction used. In the ordinary cases a moment of $\frac{wl^2}{16}$ may be taken; for small beams running into heavy columns this should be increased, but not to exceed $\frac{wl^2}{12}$.

For spans of unusual length, or for spans of materially unequal length, more exact calculations should be made. Special consideration is also required in the case of concentrated loads.

Even if the center of the span is designed for a greater bending moment than is called for by (*a*) or (*b*), the negative moment at the support should not be taken as less than the values there given.

Where beams are reinforced on the compression side, the steel may be assumed to carry its proportion of stress in accordance with the ratio of moduli of elasticity, Chapter VIII, Section 8. Reinforcing bars for compression in beams should be straight and should be two diameters in the clear from the surface of the concrete. For the positive bending moment, such reinforcement should not exceed 1 per cent of the area of the concrete. In the case of cantilever and continuous beams, tensile and compressive reinforcement over supports should extend sufficiently beyond the support and beyond the point of inflection to develop the requisite bond strength.

In construction made continuous over supports it is important that ample foundations should be provided; for unequal settlements are liable to produce unsightly if not dangerous cracks. This effect is more likely to occur in low structures.

Girders, such as wall girders, which have beams framed into one side only, should be designed to resist torsional moment arising from the negative moment at the end of the beam.

7. BOND STRENGTH AND SPACING OF REINFORCEMENT.

Adequate bond strength should be provided. The formula hereinafter given for bond stresses in beams is for straight longitudinal bars. In beams in which a portion of the reinforcement is bent up near the end, the bond stress at places, in both the straight bars and the bent bars, will be considerably greater than for all the bars straight, and the stress at some point may be several times as much as that found by considering the stress to be uniformly distributed along the bar. In restrained and cantilever beams full tensile stress exists in the reinforcing bars at the point of support and the bars should be anchored in the support sufficiently to develop this stress.

In case of anchorage of bars, an additional length of bar should be provided beyond that found on the assumption of uniform bond stress, for the reason that before the bond resistance at the end of the bar can be developed the bar may have begun to slip at another point and "running" resistance is less than the resistance before slip begins.

Where high bond resistance is required, the deformed bar is a suitable means of supplying the necessary strength. But it should be recognized that even with a deformed bar initial slip occurs at early loads, and that the ultimate loads obtained in the usual tests for bond resistance may be misleading. Adequate bond strength throughout the length of a bar is preferable to end anchorage, but, as an additional safeguard, such anchorage may properly be used in special cases. Anchorage furnished by short bends at a right angle is less effective than by hooks consisting of turns through 180 deg.

The lateral spacing of parallel bars should be not less than three diameters from center to center, nor should the distance from the side of the beam to the center of the nearest bar be less than two diameters. The clear spacing between two layers of bars should be not less than 1 in. The use of more than two layers is not recommended, unless the layers are tied together by adequate metal connections, particularly at and near points where bars are bent up or bent down. Where more than one layer is used at least all bars above the lower layer should be bent up and anchored beyond the edge of the support.

8. DIAGONAL TENSION AND SHEAR.

When a reinforced concrete beam is subjected to flexural action, diagonal tensile stresses are set up. A beam without web reinforcement will fail if these stresses exceed the tensile strength of the concrete. When web reinforcement, made up of stirrups or of diagonal bars secured to the longitudinal reinforcement, or of longitudinal reinforcing bars bent up at several points, is used, new conditions prevail, but even in this case at the beginning of loading the diagonal tension developed is taken principally by the concrete, the deformations which are developed in the concrete permitting but little stress to be taken by the web reinforcement. When the resistance of the concrete to the diagonal tension is overcome at any point in the depth of the beam, greater stress is at once set up in the web reinforcement.

For homogeneous beams the analytical treatment of diagonal tension is not very complex—the diagonal tensile stress is a function of the horizontal and vertical shearing stresses and of the horizontal tensile stress at the point considered, and as the intensity of these three stresses varies from the neutral axis to the remotest fiber, the intensity of the diagonal tension will be different at different points in the section, and will change with different proportionate dimensions of length to depth of beam. For the composite structure of reinforced concrete beams, an analysis of the web stresses, and particularly of the diagonal tensile stresses, is very complex; and when the variations due to a change from no horizontal tensile stress in the concrete at remotest fiber to the presence of horizontal tensile stress at some point below the neutral axis are considered, the problem becomes more complex and indefinite. Under these circumstances, in designing recourse is had to the use of the calculated vertical shearing stress as a means of comparing or measuring the diagonal tensile stresses developed, it being understood that the vertical shearing stress is not the numerical equivalent of the diagonal tensile stress, and that there is not even a constant ratio between them. It is here recommended that the maximum vertical shearing stress in a section be used as the means of comparison of the resistance to diagonal tensile stress developed in the concrete in beams not having web reinforcement.

Even after the concrete has reached its limit of resistance to diagonal tension, if the beam has web reinforcement, conditions of beam action will continue to prevail, at least through the compression area, and the web reinforcement will be called on to resist only a part of the web stresses. From experiments with beams it is concluded that it is safe practice to use only two-thirds of the external vertical shear in making calculations of the stresses that come on stirrups, diagonal web pieces, and bent-up bars, and it is here recommended for calculations in designing that two-thirds of the external vertical shear be taken as producing stresses in web reinforcement.

It is well established that vertical members attached to or looped about horizontal members, inclined members secured to horizontal members in such a way as to insure against slip, and the bending of a part of the longitudinal reinforcement at an angle, will increase the strength of a beam against failure by diagonal tension, and that a well-designed and well-distributed web reinforcement may under the best conditions increase the total vertical shear carried to a value as much as three times that obtained when the bars are all horizontal and no web reinforcement is used.

When web reinforcement comes into action as the principal tension web resistance, the bond stresses between the longitudinal bars and the concrete are not distributed as uniformly along the bars as they otherwise would be, but tend to be concentrated at and near stirrups, and at and near the points where bars are bent up. When stirrups are not rigidly attached to the longitudinal bars, and the proportioning of bars and stirrup spacing is such that local slip of bars occur at stirrups, the effectiveness of the stirrups is impaired, though the presence of stirrups still gives an element of toughness against diagonal tension failure.

Sufficient bond resistance between the concrete and the stirrups or diagonals must be provided in the compression area of the beam.

The longitudinal spacing of vertical stirrups should not exceed one-half the depth of beam, and that of inclined members should not exceed three-fourths of the depth of beam.

Bending of longitudinal reinforcing bars at an angle across the web of the beam may be considered as adding to diagonal tension resistance for a horizontal distance from the point of bending equal to three-fourths of the depth of beam. Where the bending is made at two or more points, the distance between points of bending should not exceed three-fourths of the depth of the beam. In the case of a restrained beam the effect of bending up a bar at the bottom of the beam in resisting diagonal tension may not be taken as extending beyond a section at the point of inflection, and the effect of bending down a bar in the region of negative moment may be taken as extending from the point of bending down of bar nearest the support to a section not more than three-fourths of the depth of beam beyond the point of bending down of bar farthest from the support but not beyond the point of inflection. In case stirrups are used in the beam away from the region in which the bent bars are considered effective, a stirrup should be placed not farther than a distance equal to one-fourth the depth of beam from the limiting sections defined above. In case the web resistance required through the region of bent bars is greater than that furnished by the bent bars, sufficient additional web reinforcement in the form of stirrups or attached diagonals should be provided. The higher resistance to diagonal tension stresses given by unit frames having the stirrups and bent-up bars securely connected together both longitudinally and laterally is worthy of recognition. It is necessary that a limit be placed on the amount of shear which may be allowed in a beam; for when web reinforcement sufficiently efficient to give very high web resistance is used, at the higher stresses the concrete in the beam becomes checked and cracked in such a way as to endanger its durability as well as its strength.

The section to be taken as the critical section in the calculation of shearing stresses will generally be the one having the maximum vertical shear, though experiments show that the section at which diagonal tension failures occur is not just at a support even though the shear at the latter point be much greater.

In the case of restrained beams, the first stirrup or the point of bending down of bar should be placed not farther than one-half of the depth of beam away from the face of the support.

It is important that adequate bond strength or anchorage be provided to develop fully the assumed strength of all web reinforcement.

Low bond stresses in the longitudinal bars are helpful in giving resistance against diagonal tension failures and anchorage of longitudinal bars at the ends of the beams or in the supports is advantageous.

It should be noted that it is on the tension side of a beam that diagonal tension develops in a critical way, and that proper connection should always be made between stirrups or other web reinforcement and the longitudinal tension reinforcement, whether the latter is on the lower side of the beam or on its upper side. Where negative moment exists, as is the case near the supports in a continuous beam, web reinforcement to be effective must be looped over or wrapped around or be connected with the longitudinal tension reinforcing bars at the top of the beam in the same way as is necessary at the bottom of the beam at sections where the bending moment is positive.

Inasmuch as the smaller the longitudinal deformations in the horizontal reinforcement are, the less the tendency for the formation of diagonal cracks, a beam will be strengthened against diagonal tension failure by so arranging and proportioning the horizontal reinforcement that the unit stresses at points of large shear shall be relatively low.

It does not seem feasible to make a complete analysis of the action of web reinforcement, and more or less empirical methods of calculation are therefore employed. Limiting values of working stresses for different types of web reinforcement are given in Chapter VIII, Section 5. The conditions apply to cases commonly met in design. It is assumed that adequate bond resistance or anchorage of all web reinforcement will be provided.

When a flat slab rests on a column, or a column bears on a footing, the vertical shearing stresses in the slab or footing immediately adjacent to the column are termed punching shearing stresses. The element of diagonal tension, being a function of the bending moment as well as of shear, may be small in such cases, or may be otherwise provided for. For this reason the permissible limit of stress for punching shear may be higher than the allowable limit when the shearing stress is used as a means of comparing diagonal tensile stress. The working values recommended are given in Chapter VIII, Section 5.

9. COLUMNS.

By columns are meant compression members of which the ratio of unsupported length to least width exceeds about four, and which are provided with reinforcement of one of the forms hereafter described.

It is recommended that the ratio of unsupported length of column to its least width be limited to 15.

The effective area of hooped columns or columns reinforced with structural shapes shall be taken as the area within the circle enclosing the spiral or the polygon enclosing the structural shapes.

Columns may be reinforced by longitudinal bars; by bands, hoops, or spirals, together with longitudinal bars; or by structural forms which are sufficiently rigid to have value in themselves as columns. The general effect of closely spaced hooping is to greatly increase the toughness of the column and to add to its ultimate strength, but hooping has little effect on its behavior within the limit of elasticity. It thus renders the concrete a safer and more reliable material, and should permit the use of a somewhat higher working stress. The beneficial effects of toughening are adequately provided by a moderate amount of hooping, a larger amount serving mainly to increase the ultimate strength and the deformation possible before ultimate failure.

Composite columns of structural steel and concrete in which the steel forms a column by itself should be designed with caution. To classify this type as a concrete column reinforced with structural steel is hardly permissible, as the steel generally will take the greater part of the load. When this type of column is used, the concrete should not be relied upon to tie the steel units together nor to transmit stresses from one unit to another. The units should be adequately tied together by tie plates or lattice bars, which, together with other details, such as splices, etc., should be designed in conformity with standard practice for structural steel. The concrete may exert a beneficial effect in restraining the steel from lateral deflection and also in increasing the carrying capacity of the column. The proportion of load to be carried by the concrete will depend on the form of the column and the method of construction. Generally, for high percentages of steel, the concrete will develop relatively low unit-stresses, and caution should be used in placing dependence on the concrete.

The following recommendations are made for the relative working stresses in the concrete for the several types of columns:

(*a*) Columns with longitudinal reinforcement to the extent of not less than 1 per cent and not more than 4 per cent, and with lateral ties of not less than $\frac{1}{4}$ in. in diameter 12 in. apart, nor more than 16 diameters of the longitudinal bar: the unit stress recommended for axial compression, on concrete piers having a length not more than four diameters, in Chapter VIII, Section 3.

(*b*) Columns reinforced with not less than 1 per cent and not more than 4 per cent of longitudinal bars and with circular hoops or spirals not less than 1 per cent of the volume of the concrete and as hereinafter specified: a unit stress 55 per cent higher than given for (*a*), provided the ratio of unsupported length of column to diameter of the hooped core is not more than 10.

The foregoing recommendations are based on the following conditions:

It is recommended that the minimum size of columns to which the working stresses may be applied be 12 in. out to out.

In all cases longitudinal reinforcement is assumed to carry its proportion of stress in accordance with Section 3 (*c*) 6 of this chapter. The hoops or bands are not to be counted on directly as adding to the strength of the column.

Longitudinal reinforcement bars should be maintained straight, and should have sufficient lateral support to be securely held in place until the concrete has set.

Where hooping is used, the total amount of such reinforcement shall be not less than 1 per cent of the volume of the column, enclosed. The clear spacing of such hooping shall be not greater than one-sixth the diameter of the enclosed column and preferably not greater than one-tenth, and in no case more than 2½ in. Hooping is to be circular and the ends of bands must be united in such a way as to develop their full strength. Adequate means must be provided to hold bands or hoops in place so as to form a column, the core of which shall be straight and well centered. The strength of hooped columns depends very much upon the ratio of length to diameter of hooped core, and the strength due to hooping decreases rapidly as this ratio increases beyond five. The working stresses recommended are for hooped columns with a length of not more than ten diameters of the hooped core.

The Committee has no recommendation to make for a formula for working stresses for columns longer than ten diameters.

Bending stresses due to eccentric loads, such as unequal spans of beams, and to lateral forces, must be provided for by increasing the section until the maximum stress does not exceed the values above specified. Where tension is possible in the longitudinal bars of the column, adequate connection between the ends of the bars must be provided to take this tension.

10. REINFORCING FOR SHRINKAGE AND TEMPERATURE STRESSES.

When areas of concrete too large to expand and contract freely as a whole are exposed to atmospheric conditions, the changes of form due to shrinkage and to action of temperature are such that cracks may occur in the mass unless precautions are taken to distribute the stresses so as to prevent the cracks altogether or to render them very small. The distance apart of the cracks, and consequently their size, will be directly proportional to the diameter of the reinforcement and to the tensile strength of the concrete, and inversely proportional to the percentage of reinforcement and also to its bond resistance per unit of surface area. To be most effective, therefore, reinforcement (in amount generally not less than one-third of one per cent of the gross area) of a form which will develop a high bond resistance should be placed near the exposed surface and be well distributed. Where openings occur the area of cross-section of the reinforcement should not be reduced. The allowable size and spacing of cracks depends on various considerations, such as the necessity for water-tightness, the importance of appearance of the surface, and the atmospheric changes.

The tendency of concrete to shrink makes it necessary, except where expansion is provided for, to thoroughly connect the component parts of the frame of articulated structures, such as floor and wall members in buildings, by the use of suitable reinforcing material. The amount of reinforcement for such connection should bear some relation to the size of the members connected, larger and heavier members requiring stronger connections. The reinforcing bars should be extended beyond the critical section far enough, or should be sufficiently anchored to develop their full tensile strength.

11. FLAT SLAB.

The continuous flat slab reinforced in two or more directions and built monolithically with the supporting columns (without beams or girders) is a type of construction which is now extensively used and which has recognized advantages for certain types of structures as, for example, warehouses in which large, open floor space is desired. In its construction, there is excellent opportunity for inspecting the position of the reinforcement. The conditions attending depositing and placing of concrete are favorable to securing uniformity and soundness in the concrete. The recommendations in the following paragraphs relate to flat slabs extending over several rows of panels in each direction. Necessarily the treatment is more or less empirical.

The coefficients and moments given relate to uniformly distributed loads.

(*a*) *Column Capital.*—It is usual in flat slab construction to enlarge the supporting columns at their top, thus forming column capitals. The size and shape of the column capital affect the strength of the structure in several ways. The moment of the external forces which the slab is called upon to resist is dependent upon the size of the capital; the section of the slab immediately above the upper periphery of the capital carries the highest amount of punching shear; and the bending moment developed in the column by an eccentric or unbalanced loading of the slab is greatest at the under surface of the slab. Generally the horizontal section of the column capital should be round or square with rounded corners. In oblong panels the section may be oval or oblong, with dimensions proportional to the panel dimensions. For computation purposes, the diameter of the column capital will be considered to be measured where its vertical thickness is at least 1½ in., provided the slope of the capital below this point nowhere makes an angle with the vertical of more than 45 deg. In case a cap is placed above the column capital, the part of this cap within a cone made by extending the lines of the column capital upward at the slope of 45 deg. to the bottom of the slab or dropped panel may be considered as part of the column capital in determining the diameter for design purposes. Without attempting to limit the size of the column capital for special cases, it is recommended that the diameter of the column capital (or its dimension parallel to the edge of the panel) generally be made not less than one-fifth of the dimension of the panel from center to center of adjacent columns. A diameter equal to 0.225 of the panel length has been used quite widely and acceptably. For heavy loads or large panels especial attention should be given to designing and reinforcing the column capital with respect to compressive stresses and bending moments. In the case of heavy loads or large panels, and where the conditions of the panel loading or variations in panel length or other conditions cause high bending stresses in the column, and also for column capitals smaller than the size herein recommended, especial attention should be given to designing and reinforcing the column capital with respect to compression and to rigidity of connection to floor slab.

(*b*) *Dropped Panel.*—In one type of construction the slab is thickened throughout an area surrounding the column capital. The square or oblong of thickened slab thus formed is called a dropped panel or a drop. The thickness and the width of the dropped panel may be governed by the amount of resisting moment to be provided (the compressive stress in the concrete being dependent upon both thickness and width), or its thickness may be governed by the resistance to shear required at the edge of the column capital and its width by the allowable compressive stresses and shearing stresses in the thinner portion of the slab adjacent to the dropped panel. Generally, however, it is recommended that the width of the dropped panel be at least four-tenths of the corresponding side of the panel as measured from center to center of columns, and that the offset in thickness be not more than five-tenths of the thickness of the slab outside the dropped panel.

(*c*) *Slab Thickness.*—In the design of a slab, the resistance to bending and to shearing forces will largely govern the thickness, and, in the case of large panels with light loads, resistance to deflection may be a controlling factor. The following formulas for minimum thicknesses are recommended as general rules of design when the diameter of the column capital is not less than one-fifth of the dimension of the panel from center to center of adjacent columns, the larger dimension being used in the case of oblong panels. For notation, let

t = total thickness of slab in inches.
L = panel length in feet.
w = sum of live load and dead load in pounds per square foot.

Then, for a slab without dropped panels, minimum $t=0.024\ L\sqrt{w}+1\frac{1}{2}$; for a slab with dropped panels, minimum $t=0.02\ L\sqrt{w}+1$; for a dropped panel whose width is four-tenths of the panel length, minimum $t=0.03\ L\sqrt{w}+1\frac{1}{2}$.

In no case should the slab thickness be made less than six inches, nor should the thickness of a floor slab be made less than one-thirty-second of the panel length, nor the thickness of a roof slab less than one-fortieth of the panel length.

(*d*) *Bending and Resisting Moments in Slabs.*—If a vertical section of a slab be taken across a panel along a line midway between columns, and if another section be taken along an edge of the panel parallel to the first section, but skirting the part of the periphery of the column capitals at the two corners of the panels, the moment of the couple formed by the external load on the half panel, exclusive of that over the column capital (sum of dead and live load) and the resultant of the external shear or reaction at the support at the two column capitals (see Fig. 1), may be found by ordinary static analysis. It will be noted that the edges of the area here considered are along lines of zero shear except around the column capitals. This moment of the external forces acting on the half panel will be resisted by the numerical sum of (*a*) the moment of the internal stresses at the section of the panel midway between columns (positive resisting

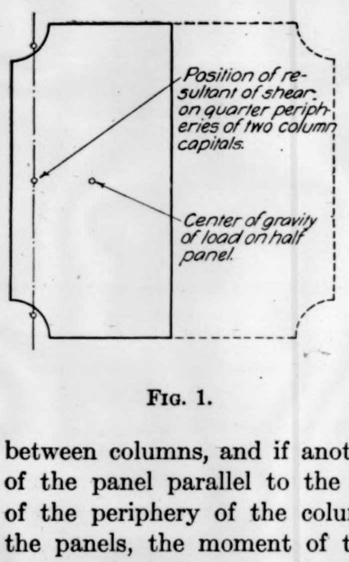
Position of resultant of shear on quarter peripheries of two column capitals.
Center of gravity of load on half panel.

FIG. 1.

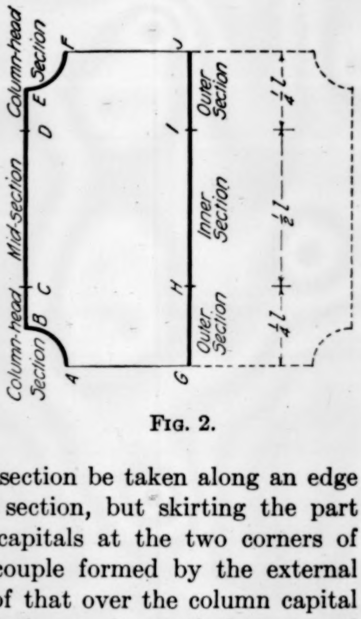
Column-head Section
F
E
D
J
Outer Section
I
Mid-section
Inner Section
C
B
H
Column-head Section
A
G
Outer Section
L/4
L/2
L/4

FIG. 2.

moment) and (*b*) the moment of the internal stresses at the section referred to at the end of the panel (negative resisting moment). In the curved portion of the end section (that skirting the column), the stresses considered are the components which act parallel to the normal stresses on the straight portion of the section. Analysis shows that, for a uniformly distributed load, and round columns, and square panels, the numerical sum of the positive moment and the negative moment at the two sections named is given quite closely by the equation

$$M_x = \frac{1}{8} wl \left(l - \frac{2}{3} c\right)^2.$$

In this formula and in those which follow relating to oblong panels,

w = sum of the live and dead load per unit of area;
l = side of a square panel measured from center to center of columns;
l_1 = one side of the oblong panel measured from center to center of columns;
l_2 = other side of oblong panel measured in the same way;
c = diameter of the column capital;
M_x = numerical sum of positive moment and negative moment in one direction.
M_y = numerical sum of positive moment and negative moment in the other direction.

(See paper and closure, Statical Limitations upon the Steel Requirement in Reinforced Concrete Flat Slab Floors, by John R. Nichols, Jun. Am. Soc. C. E., Transactions Am. Soc. C. E., Vol. LXXVII.)

For oblong panels, the equations for the numerical sums of the positive moment and the negative moment at the two sections named become,

$$M_x = \frac{1}{8} wl_2 \left(l_1 - \frac{2}{3} c\right)^2$$

$$M_y = \frac{1}{8} wl_1 \left(l_2 - \frac{2}{3} c\right)^2$$

where M_x is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension l_2, and M_y is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension l_1.

What proportion of the total resistance exists as positive moment and what as negative moment is not readily determined. The amount of the positive moment and that of the negative moment may be expected to vary somewhat with the design of the slab. It seems proper, however, to make the division of total resisting moment in the ratio of three-eighths for the positive moment to five-eighths for the negative moment.

With reference to variations in stress along the sections, it is evident from conditions of flexure that the resisting moment is not distributed uniformly along either the section of positive moment or that of negative moment. As the law of the distribution is not known definitely, it will be necessary to make an empirical apportionment along the sections; and it will be considered sufficiently accurate generally to divide the sections into two parts and to use an average value over each part of the panel section.

The relatively large breadth of structure in a flat slab makes the effect of local variations in the concrete less than would be the case for narrow members like beams. The tensile resistance of the concrete is less affected by cracks. Measurements of deformations in buildings under heavy load indicate the presence of considerable tensile resistance in the concrete, and the presence of this tensile resistance acts to decrease the intensity of the compressive stresses. It is believed that the use of moment coefficients somewhat less than those given in a preceding paragraph as derived by analysis is warranted, the calculations of resisting moment and stresses in concrete and reinforcement being made according to the assumptions specified in this report and no change being made in the values of the working stresses ordinarily used. Accordingly, the values of the moments which are recommended for use are somewhat less than those derived by analysis. The values given may be used when the column capitals are round, oval, square, or oblong.

(e) *Names for Moment Sections.*—For convenience, that portion of the section across a panel along a line midway between columns which lies within the middle two quarters of the width of the panel (HI, Fig. 2) will be called the inner section, and that portion in the two outer quarters of the width of the panel

(GH and IJ, Fig. 2) will be called the outer sections. Of the section which follows a panel edge from column capital to column capital and which includes the quarter peripheries of the edges of two column capitals, that portion within the middle two quarters of the panel width (CD, Fig. 2) will be called the mid-section, and the two remaining portions (ABC and DEF, Fig. 2), each having a projected width equal to one-fourth of the panel width, will be called the column-head sections.

(*f*) *Positive Moment.*—For a square interior panel, it is recommended that the positive moment for a section in the middle of a panel extending across its width be taken as $\frac{1}{25} wl \ (l - \frac{2}{3} c)^2$. Of this moment, at least 25 per cent should be provided for in the inner section; in the two outer sections of the panel at least 55 per cent of the specified moment should be provided for in slabs not having dropped panels, and at least 60 per cent in slabs having dropped panels, except that in calculations to determine necessary thickness of slab away from the dropped panel at least 70 per cent of the positive moment should be considered as acting in the two outer sections.

(*g*) *Negative Moment.*—For a square interior panel, it is recommended that the negative moment for a section which follows a panel edge from column capital to column capital and which includes the quarter peripheries of the edges of the two column capitals (the section altogether forming the projected width of the panel) be taken as $\frac{1}{15} wl \ (l - \frac{2}{3} c)^2$. Of this negative moment, at least 20 per cent should be provided for in the mid-section and at least 65 per cent in the two column-head sections of the panel, except that in slabs having dropped panels at least 80 per cent of the specified negative moment should be provided for in the two column-head sections of the panel.

(*h*) *Moments for Oblong Panels.*—When the length of a panel does not exceed the breadth by more than 5 per cent, computation may be made on the basis of a square panel with sides equal to the mean of the length and the breadth.

When the long side of an interior oblong panel exceeds the short side by more than one-twentieth and by not more than one-third of the short side, it is recommended that the positive moment be taken as $\frac{1}{25} wl_2 (l_1 - \frac{2}{3} c)^2$ on a section parallel to the dimension l_2, and $\frac{1}{25} wl_1 (l_2 - \frac{2}{3} c)^2$ on a section parallel to the dimension l_1; and that the negative moment be taken as $\frac{1}{15} wl_2 (l_1 - \frac{2}{3} c)^2$ on a section at the edge of the panel corresponding to the dimension l_2, and $\frac{1}{15} wl_1 (l_2 - \frac{2}{3} c)^2$ at a section in the other direction. The limitations of the apportionment of moment between inner section and outer section and between mid-section and column-head sections may be the same as for square panels.

(*i*) *Wall Panels.*—The coefficient of negative moment at the first row of columns away from the wall should be increased 20 per cent over that required for interior panels, and likewise the coefficient of positive moment at the section half way to the wall should be increased by 20 per cent. If girders are not provided along the wall or the slab does not project as a cantilever beyond the column line, the reinforcement parallel to the wall for the negative moment in the column-head section and for the positive moment in the outer section should be increased by 20 per cent. If the wall is carried by the slab this concentrated load should be provided for in the design of the slab. The coefficient of negative moments at the wall to take bending in the direction perpendicular to the wall line may be determined by the conditions of restraint and fixedness as found from the relative stiffness of columns and slab, but in no case should it be taken as less than one-half of that for interior panels.

(*j*) *Reinforcement.*—In the calculation of moments all the reinforcing bars which cross the section under consideration and which fulfill the requirements given under Paragraph (*l*) of this chapter may be used. For a column-head section reinforcing bars parallel to the straight portion of the section do not contribute to the negative resisting moment for the column-head section in question. In the case of four-way reinforcement the sectional area of the diagonal bars multiplied by the sine of the angle between the diagonal of the panel and the straight portion of the section under consideration may be taken to act as reinforcement in a rectangular direction.

(*k*) *Point of Inflection.*—For the purpose of making calculations of moments at sections away from the sections of negative moment and positive moment already specified, the point of inflection on any line parallel to a panel edge may be taken as one-fifth of the clear distance on that line between the two sections of negative moment at the opposite ends of the panel indicated in Paragraph (*e*), of this chapter. For slabs having dropped panels the coefficient of one-fourth should be used instead of one-fifth.

(*l*) *Arrangement of Reinforcement.*—The design should include adequate provision for securing the reinforcement in place so as to take not only the maximum moments but the moments at intermediate sections. All bars in rectangular bands or diagonal bands should extend on each side of a section of maximum moment, either positive or negative, to points at least twenty diameters beyond the point of inflection as defined herein or be hooked or anchored at the point of inflection. In addition to this provision bars in diagonal bands used as reinforcement for negative moment should extend on each side of a line drawn through the column center at right angles to the direction of the band at least a distance equal to thirty-five one-hundredths of the panel length, and bars in diagonal bands used as reinforcement for positive moment should extend on each side of a diagonal through the center of the panel at least a distance equal to thirty-five one-hundredths of the panel length; and no splice by lapping should be permitted at or near regions of maximum stress except as just described. Continuity of reinforcing bars is considered to have advantages, and it is recommended that not more than one-third of the reinforcing bars in any direction be made of a length less than the distance center to center of columns in that direction. Continuous bars should not all be bent up at the same point of their length, but the zone in which this bending occurs should extend on each side of the assumed point of inflection, and should cover a width of at least one-fifteenth of the panel length. Mere draping of the bars should not be permitted. In four-way reinforcement the position of the bars in both diagonal and rectangular directions may be considered in determining whether the width of zone of bending is sufficient.

(*m*) *Reinforcement at Construction Joints.*—It is recommended that at construction joints extra reinforcing bars equal in section to 20 per cent of the amount necessary to meet the requirements for moments at the section where the joint is made be added to the reinforcement, these bars to extend not less than 50 diameters beyond the joint on each side.

(*n*) *Tensile and Compressive Stresses.*—The usual method of calculating the tensile and compressive stresses in the concrete and in the reinforcement, based on the assumptions for internal stresses given in this chapter, should be followed. In the case of the dropped panel the section of the slab and dropped panel may be considered to act integrally for a width equal to the width of the column-head section.

(*o*) *Provision for Diagonal Tension and Shear.*—In calculations for the shearing stress which is to be used as the means of measuring the resistance to diagonal tension stress, it is recommended that the total vertical shear on two column-head sections constituting a width equal to one-half the lateral dimension of the panel, for use in the formula for determining critical shearing stresses, be considered to be one-fourth of the total dead and live load on a panel for a slab of uniform thickness, and to be three-tenths of the sum of the dead and live loads on a panel for a slab with dropped panels. The formula for shearing unit stress given in Chapter X of this report may then be written $v = \frac{0.25W}{bjd}$ for slabs of uniform thickness, and $v = \frac{0.30W}{bjd}$ for slabs with dropped panels, where W is the sum of the dead and live load on a panel, b is half the lateral dimension of the panel measured from center to center of columns, and jd is the lever arm of the resisting couple at the section.

The calculation of what is commonly called punching shear may be made on the assumption of a uniform distribution over the section of the slab around the periphery of the column capital and also of a uniform distribution over the section of the slab around the periphery of the dropped panel, using in each case an amount of vertical shear greater by 25 per cent than the total vertical shear on the section under consideration.

The values of working stresses should be those recommended for diagonal tension and shear in Chapter VIII, Section 5.

(*p*) *Walls and Openings.*—Girders or beams should be constructed to carry walls and other concentrated loads which are in excess of the working capacity of the slab. Beams should also be provided in case openings in the floor reduce the working strength of the slab below the required carrying capacity.

(*q*) *Unusual Panels.*—The coefficients, apportionments, and thicknesses recommended are for slabs which have several rows of panels in each direction, and in which the size of the panels is approximately the same. For structures having a width of one, two, or three panels, and also for slabs having panels of markedly different sizes, an analysis should be made of the moments developed in both slab and columns, and the values given herein modified accordingly. Slabs with paneled ceiling or with depressed paneling in the floor are to be considered as coming under the recommendations herein given.

(*r*) *Bending Moments in Columns.*—Provision should be made in both wall columns and interior columns for the bending moment which will be developed by unequally loaded panels, eccentric loading, or uneven spacing of columns. The amount of moment to be taken by a column will depend upon the relative stiffness of columns and slab, and computations may be made by rational methods, such as the principle of least work, or of slope and deflection. Generally, the larger part of the unequalized negative moment will be transmitted to the columns, and the column should be designed to resist this bending moment. Especial attention should be given to wall columns and corner columns.

CHAPTER VIII.

WORKING STRESSES.

1. GENERAL ASSUMPTIONS.

The following working stresses are recommended for static loads. Proper allowances for vibration and impact are to be added to live loads where necessary to produce an equivalent static load before applying the unit stresses in proportioning parts.

In selecting the permissible working stress on concrete, the designer should be guided by the working stresses usually allowed for other materials of construction, so that all structures of the same class composed of different materials may have approximately the same degree of safety.

The following recommendations as to allowable stresses are given in the form of percentages of the ultimate strength of the particular concrete which is to be used; this ultimate strength is that developed at an age of 28 days, in cylinders 8 in. in diameter and 16 in. long, of the consistency described in Chapter IV, Section 2 (*d*), made and stored under laboratory conditions. In the absence of definite knowledge in advance of construction as to just what strength may be expected, the Committee submits the following values as those which should be obtained with materials and workmanship in accordance with the recommendations of this report.

Although occasional tests may show higher results than those here given, the Committee recommends that these values should be the maximum used in design.

TABLE OF COMPRESSIVE STRENGTHS OF DIFFERENT MIXTURES OF CONCRETE.

(In Pounds per Square Inch.)

Aggregate	1 : 3*	1 : 4½*	1 : 6*	1 : 7½*	1 : 9*
Granite, trap rock	3300	2800	2200	1800	1400
Gravel, hard limestone and hard sandstone	3000	2500	2000	1600	1300
Soft limestone and sandstone	2200	1800	1500	1200	1000
Cinders	800	700	600	500	400

NOTE.—For variations in the moduli of elasticity see Chapter VIII, Section 8.

2. BEARING.

When compression is applied to a surface of concrete of at least twice the loaded area, a stress of 35 per cent of the compressive strength may be allowed in the area actually under load.

3. AXIAL COMPRESSION.

For concentric compression on a plain concrete pier, the length of which does not exceed 4 diameters, or on a column reinforced with longitudinal bars only, the length of which does not exceed 12 diameters, 22.5 per cent of the compressive strength may be allowed.

For other forms of columns the stresses obtained from the ratios given in Chapter VII, Section 9, may govern.

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* Combined volume fine and coarse aggregates measured separately.

4. COMPRESSION IN EXTREME FIBER.

The extreme fiber stress of a beam, calculated on the assumption of a constant modulus of elasticity for concrete under working stresses may be allowed to reach 32.5 per cent of the compressive strength. Adjacent to the support of continuous beams stresses 15 per cent higher may be used.

5. SHEAR AND DIAGONAL TENSION.

In calculations on beams in which the maximum shearing stress in a section is used as the means of measuring the resistance to diagonal tension stress, the following allowable values for the maximum vertical shearing stress in concrete, calculated by the method given in Chapter X, Formula 22, are recommended:

(*a*) For beams with horizontal bars only and without web reinforcement, 2 per cent of the compressive strength.

(*b*) For beams with web reinforcement consisting of vertical stirrups looped about the longitudinal reinforcing bars in the tension side of the beam and spaced horizontally not more than one-half the depth of the beam; or for beams in which longitudinal bars are bent up at an angle of not more than 45 deg. or less than 20 deg. with the axis of the beam, and the points of bending are spaced horizontally not more than three-quarters of the depth of the beam apart, not to exceed 4½ per cent of the compressive strength.

(*c*) For a combination of bent bars and vertical stirrups looped about the reinforcing bars in the tension side of the beam and spaced horizontally not more than one-half of the depth of the beam, 5 per cent of the compressive strength.

(*d*) For beams with web reinforcement (either vertical or inclined) securely attached to the longitudinal bars in the tension side of the beam in such a way as to prevent slipping of bar past the stirrup, and spaced horizontally not more than one-half of the depth of the beam in case of vertical stirrups and not more than three-fourths of the depth of the beam in the case of inclined members, either with longitudinal bars bent up or not, 6 per cent of the compressive strength.

The web reinforcement in case any is used should be proportioned by using two-thirds of the external vertical shear in

Formula 24 or 25 in Chapter X. The effect of longitudinal bars bent up at an angle of from 20 to 45 deg. with the axis of the beam may be taken at sections of the beam in which the bent up bars contribute to diagonal tension resistance as defined under Chapter VII, Section 8, as reducing the shearing stresses to be otherwise provided for. The amount of reduction of the shearing stress by means of bent up bars will depend upon their capacity, but in no case should be taken as greater than 4½ per cent of the compressive strength of the concrete over the effective cross-section of the beam (Formula 22). The limit of tensile stress in the bent up portion of the bar calculated by Formula 25, using in this formula an amount of total shear corresponding to the reduction in shearing stress assumed for the bent up bars, may be taken as specified for the working stress of steel, but in the calculations the stress in the bar due to its part as longitudinal reinforcement of the beam should be considered. The stresses in stirrups and inclined members when combined with bent up bars are to be determined by finding the amount of the total shear which may be allowed by reason of the bent up bars, and subtracting this shear from the total external vertical shear. Two-thirds of the remainder will be the shear to be carried by the stirrups, using Formulas 24 or 25 in Chapter X.

Where punching shear occurs, provided the diagonal tension requirements are met, a shearing stress of 6 per cent of the compressive strength may be allowed.

6. BOND.

The bond stress between concrete and plain reinforcing bars may be assumed at 4 per cent of the compressive strength, or 2 per cent in the case of drawn wire. In the best types of deformed bar the bond stress may be increased, but not to exceed 5 per cent of the compressive strength of the concrete.

7. REINFORCEMENT.

The tensile or compressive stress in steel should not exceed 16,000 lb. per sq. in.

In structural steel members the working stresses adopted by the American Railway Engineering Association are recommended.

8. MODULUS OF ELASTICITY.

The value of the modulus of elasticity of concrete has a wide range, depending on the materials used, the age, the range of stresses between which it is considered, as well as other conditions. It is recommended that in computations for the position of the neutral axis, and for the resisting moment of beams and for compression of concrete in columns, it be assumed as:

(*a*) One-fortieth that of steel, when the strength of the concrete is taken as not more than 800 lb. per sq. in.
(*b*) One-fifteenth that of steel, when the strength of the concrete is taken as greater than 800 lb. per sq. in. and less than 2200 lb. per sq. in.
(*c*) One-twelfth that of steel, when the strength of the concrete is taken as greater than 2200 lb. per sq. in. and less than 2900 lb. per sq. in., and
(*d*) One-tenth that of steel, when the strength of the concrete is taken as greater than 2900 lb. per sq. in.

Although not rigorously accurate, these assumptions will give safe results. For the deflection of beams which are free to move longitudinally at the supports, in using formulas for deflection which do not take into account the tensile strength developed in the concrete, a modulus of one-eighth of that of steel is recommended.

CHAPTER IX.

CONCLUSION.

In the preparation of this Final Report, 21 members have taken a more or less active part; all members have agreed to it in its present form.

The Joint Committee acknowledges its indebtedness to its sub-committee on design, Professors Talbot, Hatt and Turneaure, for their invaluable and devoted service.

The Joint Committee believes that there is a great advantage in the cooperation of the representatives of different technical societies, and trusts that a similar combination of effort may be possible, some time in the future, to review the work done by the present Committee, and to embody the additional knowledge which will certainly be obtained from further experimentation and practical experience with this important material of construction.

Respectfully submitted,

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ROBERT E. GRIFFITH,
SPENCER B. NEWBERRY,
EDWARD GODFREY,[1]
EGBERT J. MOORE,
LEONARD C. WASON.

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[1] Mr. Godfrey dissents from the Report in the whole matter of stirrups and their treatment. He would give stirrups and short shear members no recognition, for the reason that he holds that they have not shown themselves to have any definite value in tests and that analysis fails to show that any definite value can be ascribed to them; he also believes that dependence on stirrups to take end shear has resulted in much unsafe construction and some failures. He would take care of diagonal tension by bending up some of the main reinforcing rods and anchoring them for their full tensile strength beyond the edge of support. He recommends that bends be made close to the supports for the upper bends and at quarter points for the lower bends in beams carrying uniform load. For girders carrying beams bends should be made under the beams. For anchorage he recommends that the rod should extend 40 to 50 diameters beyond the point where it intersects a line drawn, at 45 deg. with the horizontal from the bottom of the beam at the face of the support.

He recommends that the stress in bent-up rods be assumed to be that obtained by multiplying the excess of shear over that taken by the concrete (at 40 or 50 lb. per sq. in.) by the secant of the inclination of the rod with the vertical.

Mr. Godfrey also dissents from all parts of the Report relating to rodded columns, or columns having longitudinal rods without close-spaced hooping, for the reason that he holds that such reinforcement has not shown itself to have any definite value in tests on columns, and that analysis fails to show that any definite value can be ascribed to it, when such analysis takes into account the necessity for toughness in all columns; he also believes that dependence on such reinforcement has led to much unsafe construction and many failures. He would recognize as reinforced concrete columns only such columns as have in addition to the longitudinal rods a complete system of close-spaced hooping. He objects to the reading of Chap. VII, Sec. 9, paragraph (*b*) as being capable of interpretation that hooped columns are given an advantage in the matter of unit stresses only below ten diameters in height. He recommends the standardization of hooped columns and suggests that columns be reinforced by

CHAPTER X.

APPENDIX.

SUGGESTED FORMULAS FOR REINFORCED CONCRETE CONSTRUCTION.

These formulas are based on the assumptions and principles given in the chapter on design.

1. STANDARD NOTATION.

(a) Rectangular Beams.

The following notation is recommended:

f_s = tensile unit stress in steel;
f_c = compressive unit stress in concrete;
E_s = modulus of elasticity of steel;
E_c = modulus of elasticity of concrete;
$n = \frac{E_s}{E_c}$;
M = moment of resistance, or bending moment in general;
A_s = steel area;
b = breadth of beam;
d = depth of beam to center of steel;
k = ratio of depth of neutral axis to depth, d;
z = depth below top to resultant of the compressive stresses;
j = ratio of lever arm of resisting couple to depth, d;
$jd = d-z$ = arm of resisting couple;
p = steel ratio $= \frac{A_s}{bd}$.

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a coil or hoops of round steel having a diameter one-fortieth of that of the external diameter of the column and eight upright rods wired to the same, the pitch of the coil being one-eighth of the column diameter. He would consider available for resisting compressive stress, the entire area of the concrete of a circular column or of an octagonal column, but no part of the longitudinal rods or hooping. In a square column only 83 per cent of the area of concrete would be considered available. The compression he would recommend on columns (for 2000-lb. concrete) would be:

$$P = 670 - 12\, l/d.$$

where P = allowable compression in pounds per square inch.
l = length of column in inches.
d = diameter of column in inches.

(*b*) *T-Beams.*

b = width of flange;
b' = width of stem;
t = thickness of flange.

(*c*) *Beams Reinforced for Compression.*

A' = area of compressive steel;
p' = steel ratio for compressive steel;
f_s' = compressive unit stress in steel;
C = total compressive stress in concrete;
C' = total compressive stress in steel;
d' = depth to center of compressive steel;
z = depth to resultant of C and C'.

(*d*) *Shear, Bond and Web Reinforcement.*

V = total shear;
V' = total shear producing stress in reinforcement;
v = shearing unit stress;
u = bond stress per unit area of bar;
o = circumference or perimeter of bar;
Σo = sum of the perimeters of all bars;
T = total stress in single reinforcing member;
s = horizontal spacing of reinforcing members.

(*e*) *Columns.*

A = total net area;
A_s = area of longitudinal steel;
A_c = area of concrete;
P = total safe load.

2. FORMULAS.

(*a*) *Rectangular Beams.*

Position of neutral axis,

$$k=\sqrt{2pn+(pn)^2}-pn \qquad \text{......................(1)}$$

Arm of resisting couple,

$$j=1-\frac{1}{3}k \quad \dots\dots\dots\dots\dots\dots (2)$$

[For $f_s=15000$ to 16000 and $f_c=600$ to 650, j may be taken at $\frac{7}{8}$.]

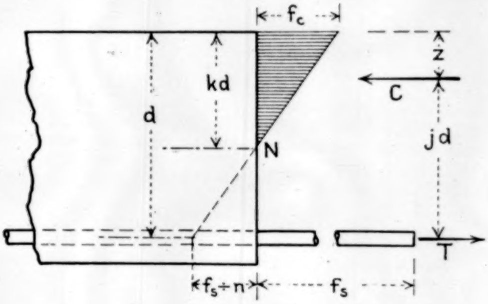

FIG. 1.

Fiber stresses,

$$f_s=\frac{M}{A_s jd}=\frac{M}{pjbd^2} \quad \dots\dots\dots\dots\dots\dots (3)$$

$$f_c=\frac{2M}{jkbd^2}=\frac{2pf_s}{k} \quad \dots\dots\dots\dots\dots\dots (4)$$

Steel ratio, for balanced reinforcement,

$$p=\tfrac{1}{2}\cdot\frac{1}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c}+1\right)} \quad \dots\dots\dots\dots\dots\dots (5)$$

(*b*) *T-Beams.*

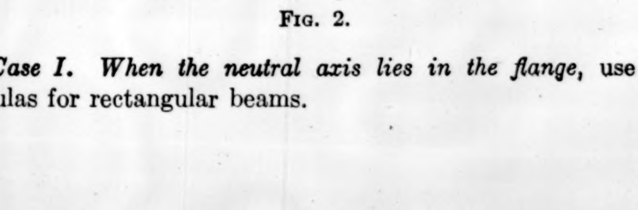

FIG. 2.

Case I. When the neutral axis lies in the flange, use the formulas for rectangular beams.

Case II. When the neutral axis lies in the stem.

The following formulas neglect the compression in the stem.

Position of neutral axis,

$$kd = \frac{2ndA_s + bt^2}{2nA_s + 2bt} \quad \text{(6)}$$

Position of resultant compression,

$$z = \frac{3kd - 2t}{2kd - t} \cdot \frac{t}{3} \quad \text{(7)}$$

Arm of resisting couple,

$$jd = d - z \quad \text{(8)}$$

Fiber stresses,

$$f_s = \frac{M}{A_s jd} \quad \text{(9)}$$

$$f_c = \frac{Mkd}{bt(kd - \frac{1}{2}t)\,jd} = \frac{f_s}{n} \cdot \frac{k}{1-k} \quad \text{(10)}$$

(For approximate results the formulas for rectangular beams may be used.)

The following formulas take into account the compression in the stem; they are recommended where the flange is small compared with the stem:

Position of neutral axis,

$$kd = \sqrt{\frac{2ndA_s + (b-b')t^2}{b'} + \left(\frac{nA_s + (b-b')t}{b'}\right)^2} - \frac{nA_s + (b-b')t}{b'} \quad \text{(11)}$$

Position of resultant compression,

$$z = \frac{(kdt^2 - \frac{2}{3}t^3)b + [(kd-t)^2\,(t + \frac{1}{3}(kd-t)\,)]b'}{t(2kd-t)b + (kd-t)^2 b'} \quad \text{(12)}$$

Arm of resisting couple,

$$jd = d - z \quad \text{(13)}$$

Fiber stresses,

$$f_s = \frac{M}{A_s jd} \quad \text{(14)}$$

$$f_c = \frac{2Mkd}{[(2kd-t)bt + (kd-t)^2 b']jd} \quad \text{(15)}$$

(c) *Beams Reinforced for Compression.*

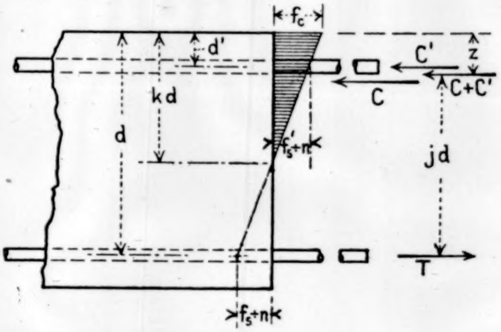

FIG. 3.

Position of neutral axis,

$$k=\sqrt{2n\left(p+p'\frac{d'}{d}\right)+n^2(p+p')^2}-n(p+p') \quad \ldots\ldots\ldots\ldots (16)$$

Position of resultant compression,

$$z=\frac{\frac{1}{3}k^3d+2p'nd'\left(k-\frac{d'}{d}\right)}{k^2+2p'n\left(k-\frac{d'}{d}\right)} \quad \ldots\ldots\ldots\ldots (17)$$

Arm of resisting couple,

$$jd=d-z \quad \ldots\ldots\ldots\ldots (18)$$

Fiber stresses,

$$f_c=\frac{6M}{bd^2\left[3k-k^2+\frac{6p'n}{k}\left(k-\frac{d'}{d}\right)\left(1-\frac{d'}{d}\right)\right]} \quad \ldots\ldots (19)$$

$$f_s=\frac{M}{pjbd^2}=nf_c\frac{1-k}{k} \quad \ldots\ldots\ldots\ldots (20)$$

$$f_s'=nf_c\frac{k-\frac{d'}{d}}{k} \quad \ldots\ldots\ldots\ldots (21)$$

(d) *Shear, Bond, and Web Reinforcement.*

For rectangular beams,

$$v=\frac{V}{bjd} \quad \ldots\ldots\ldots\ldots (22)$$

$$u=\frac{V}{jd\,.\,\Sigma o} \quad \ldots\ldots\ldots\ldots (23)$$

[For approximate results *j* may be taken at $\frac{7}{8}$.]

The stresses in web reinforcement may be estimated by means of the following formulas:

Vertical web reinforcement,

$$T = \frac{V's}{jd} \quad \text{.........................(24)}$$

Bars bent up at angles between 20 and 45 deg. with the horizontal and web members inclined at 45 deg.,

$$T = \frac{3}{4}\,\frac{V's}{jd} \quad \text{.........................(25)}$$

In the text of the report it is recommended that two-thirds of the external vertical shear (total shear) at any section be taken as the amount of total shear producing stress in the web reinforcement. V' therefore equals two-thirds of V.

The same formulas apply to beams reinforced for compression as regards shear and bond stress for tensile steel.

For T-Beams,

$$v = \frac{V}{b'jd} \quad \text{.........................(26)}$$

$$u = \frac{V}{jd\,.\,\Sigma o} \quad \text{.........................(27)}$$

[For approximate results j may be taken at $\frac{7}{8}$.]

(*e*) *Columns.*

Total safe load,

$$P = f_c(A_c + nA_s) = f_cA(1 + (n-1)p) \quad \text{...............(28)}$$

Unit stresses,

$$f_c = \frac{P}{A(1+(n-1)p)} \quad \text{....................(29)}$$

$$f_s = nf_c \quad \text{.........................(30)}$$

DISCUSSION.

Mr. Humphrey.

Mr. Richard L. Humphrey (*Secretary of Committee C-2*).— This report of Committee C-2 is merely a transmittal of the final report of the Joint Committee on Concrete and Reinforced Concrete. Committee C-2 came into existence following the adoption of a resolution by the American Society of Civil Engineers at its Asheville convention in 1902, which recommended the appointment of the Committee on Reinforced Concrete, and suggested that such a committee confer with similar committees of the American Society for Testing Materials, and the American Railway Engineering and Maintenance of Way Association. These several committees organized as the Joint Committee on Concrete and Reinforced Concrete, to which there were added subsequently committees of the Portland Cement Association and the American Concrete Institute. Since the American Society of Civil Engineers, under its precedent, was not supposed to draft specifications, the Joint Committee devoted its energies to the development of the engineering principles of reinforced concrete.

While this work was not considered by your committee to be germane to the work of this Society, inasmuch as it had accepted the invitation of another society to participate in this work, it cooperated in developing the engineering principles of reinforced concrete. Your committee is now ready to take the next step which will be more in line with the work of this Society, namely, the preparation of specifications for reinforced concrete. Using the Joint Committee's report as a basis, it will, during the year, begin the preparation of a specification for reinforced concrete.

The report of the Joint Committee on Concrete and Reinforced Concrete is presented as information and the committee recommends that it be published in the Proceedings as a record of this work. To bring the matter before the Society, I move that the report here submitted be received and published in the Proceedings. [Motion seconded.]

Mr. Enright. MR. BERNARD ENRIGHT (*presented in written form and read by the Secretary*).—A perusal of the splendid report of Committee C-2 on Reinforced Concrete cannot but impress the reader with its thoroughness and with an appreciation of what an enormously valuable addition it is to the literature of the field covered—it is practically above criticism.

If any suggestion at all were pertinent, it might possibly be in connection with the specifications covering "Fine Aggregate", in Chapter III, Section 2, page 216, where "an age of not less than 7 days" is stated as the period at which the mortar containing the fine aggregate under test, shall equal, in tensile or in compressive strength, a similar mortar with standard Ottawa sand replacing the fine aggregate referred to.

It would seem that this period could with advantage be made definitely either the 7 days, the 28 days, or some intervening period. The reason for this suggestion lies in the fact that there is frequently a very wide difference in the comparison between the strengths of two such mortars at the 7-day period and at the 28-day period. Very often a mortar containing the fine aggregate under test will show considerably less strength, at the 7-day period, than will a similar mortar with standard Ottawa sand, while it may equal or even surpass the latter in strength at the 28-day period.

Where the fine aggregate is subjected to inspection sufficiently in advance of use, the 28-day period can readily be adopted as the deciding period in case the 7-day results render such adoption advisable. Where the fine aggregate is subjected to inspection only shortly prior to its use, however, the user would probably be disinclined to wait for results past the 7-day period, and aggregate failing at 7 days but passing at 28 days would be liable to rejection as a result.

Mr. Rhett. MR. A. H. RHETT (*presented in written form and read by the Secretary*).—The writer feels that some exception may legitimately be taken to much of Section 4 of Chapter VI on "Waterproofing," page 226.

The first paragraph states that "Experience shows, that when mortar or concrete is proportioned to obtain the greatest practicable density and is mixed to the proper consistency, the resulting mortar or concrete is impervious under moderate pressure." It is quite true that experience has shown this so **Mr. Rhett.** far as laboratory experiments are concerned, but it is equally true that "experience" has most emphatically proven that in the field, in operations of any size, it is practically impossible to get "proper" proportions, "proper" mixing and "proper" consistency.

It is quite true too that much time and study have been given to the question of rendering concrete impervious by means that were more automatic and dependable than the forced acquiescence of an unwilling contractor or ignorant laborer, but certainly the ever increasing use of integral waterproofing compounds by the most prominent engineers is not confirmatory of the statement that "these expedients have generally been disappointing." It is a fact that the United States Government is, at the present moment, using enormous quantities of integral waterproofing in some of the most important concrete under construction, basing this practice on the beneficial results obtained in previous use, while it is also a fact that it is being extensively used in the concrete of the biggest railroad terminal development under way in the country to-day.

As to the statement that these expedients have generally been disappointing, "for the reason that many of these compounds have at best but temporary value, and in time lose their power of imparting impermeability to the concrete," it may be true that many of them do this; but this statement, without further qualification, entirely ignores the rational theory of integral waterproofing.

It cannot be open to legitimate question that if a material can be added to the ingredients of the concrete which will lubricate the particles, and thus reduce the necessity for rigorous tamping and also reduce the ever present temptation of the contractor to use superfluous water and chute from too steep an angle, then considerable progress has been made toward automatic imperviousness. It is also beyond question that many of the voids in concrete are due not only to the friction of the particles but to pocketing of air and water in the actual process of mixing and placing, and, however well proportioned the aggregates, these voids will still remain unless automatically closed.

Fortunately it is possible to close them automatically. Technologic Paper No. 43 of the Bureau of Standards on the

Mr. Rhett. "Hydration of Portland Cement" shows that there are latent elements in Portland cement which do not hydrate under normal conditions, but when the hydration process is once started it is accompanied by a large increase in volume of an amorphous, not crystallin, structure. As this action is slow in starting it would not commence until the concrete had set and could only occur in the vacant spaces or voids and would have no disrupting effect due to the amorphous structure of the product formed.

If then it is possible, and it is possible, to reduce the number of voids by lubrication, and to cause an action in the cement which will fill such as remain with a stable element of the cement itself, there would be nothing irrational or temporary about such an action; and in view of the simplicity of these actions it is astonishing that this subject seems to continue to be treated with such hazy comprehension.

As to the coating of concrete walls with coal-tar pitch, this may have some value in filling voids at the surface of the concrete. It is difficult to see, however, how it can have any effect in correcting temperature cracks, for the reason that at low temperatures the tar is as brittle as the concrete and it is mainly the contractive effect of low temperature which causes the breakage.

Mr. Wig. MR. R. J. WIG.—In some respects this is one of the most important reports of any that issues from this Society, and in certain respects it is most creditable. The sections on "Design" are based upon sound theory and experimental data, but many of the general statements in this report read more like the advertising literature of a cement manufacturer. In Chapter II, Section 4, on "Destructive Agencies," Paragraph (*a*), page 212, the report states:

> "Tests and experience indicate that steel sufficiently embedded in good concrete is well protected against corrosion, no matter whether located above or below water level. It is recommended that such protection be not less than 1 in. in thickness. If the concrete is porous so as to be readily permeable by water, as when the concrete is laid with a very dry consistency, the metal may corrode on account of the presence of moisture and air."

The statements made in the report of this committee are accepted by engineers generally as the last word in concrete design and

Mr. Wig. practice. In consequence, as this same statement has appeared in previous reports of the committee, practically all reinforced-concrete structures in tidewater are designed in accordance with it and practically 90 per cent of them to-day are failing, while the other 10 per cent, built more recently, will in most cases show failure within the next few years. There are structures built within the past two or three years according to the recommendations of this committee that show marked signs of failure due to the corrosion of the embedded metal, which is embedded not 1 in. but 2½ and 3 in. The rate of corrosion of embedded metal depends somewhat on the location, exposure and other conditions, but it is occurring in even brackish water.

In Paragraph (*b*) of this Section 4, under "Electrolysis," page 213, the report reads:

> "Structures containing salt or calcium chloride, even in very small quantities, are very much more susceptible to the effects of electric currents than normal concrete, the anode effect progressing much more rapidly in the presence of chlorine, and the cathode effect being greatly increased by the presence of an alkali metal."

This statement might be misunderstood, and is misunderstood by some, as applying to unreinforced concrete. Unreinforced concrete is not affected by electrolysis due to the presence of salt or calcium chloride. The statement should be modified so as to make it clear that it refers, as intended, only to reinforced-concrete structures.

In Paragraph (*c*) of Section 4, under "Sea Water," page 213, the report reads:

> "To effect the best resistance to sea water, the concrete must be proportioned, mixed and placed so as to prevent the penetration of sea water into the mass or through the joints."

Further on, page 214:

> "The concrete should be thoroughly mixed; the joints between old and new work should be made water tight; and the concrete should be kept from exposure to sea water until it is thoroughly hard and impervious."

Near the end of Section 3 of Chapter IV, on page 222, there is a counter reference to this same statement, as follows:

> "With proper care it is possible in this manner to obtain as good results under water as in the air."

Mr. Wig. Those two statements are conflicting. In the first case it is stated that the best results can be obtained only by curing the concrete before putting it in water; in the second, it is stated that equally good results can be secured by placing the concrete directly under water as can be obtained by curing it previously in the air. It is the speaker's opinion that the second statement is correct.

In Chapter II, Section 4, Paragraph (*d*), under "Acids," page 214, the report reads:

> "Dense concrete thoroughly hardened is affected appreciably only by acids which seriously injure other materials. Substances like manure that contain acids may injuriously affect green concrete, but do not affect concrete that is thoroughly hardened."

This statement is in error. The speaker has conclusive data that concrete is affected by organic acids where other materials are not affected, and it is wrong for this committee to make statements upon which they have no basis of fact, and where they have not made thorough investigation. It would be more proper to state that so far as data have been brought to their notice, no such disintegration has occurred, although it is believed that members of this committee do know of cases where disintegration has occurred due to the presence of acid.

In Paragraph (*f*) of the same section, under "Alkalies," page 214, the report reads:

> "The action of alkalies on concrete is problematical. In the reclamation of arid land where the soil is heavily charged with alkaline salts it has been found that concrete, stone, brick, iron and other materials are injured under certain conditions."

The speaker should like to ask the committee how iron is injured under alkali exposure conditions. The Bureau of Standards has been making careful field investigations for the past six years in cooperation with the Department of Agriculture, the Reclamation Service and the Portland Cement Association, and I do not know of any case where iron has been affected in a similar way to other structural material by alkalies.

The latter part of this paragraph states that:

> "It would seem that at the level of the ground water in an extremely dry atmosphere such structures are disintegrated through the rapid crystalliza-

> tion of the alkaline salts, resulting from the alternate wetting and drying of the surface. Such destructive action can be prevented by the use of a protective coating and is minimized by securing a dense concrete." **Mr. Wig.**

This statement is wholly in error. This effect cannot be prevented by the application of a surface coating, and the speaker should like to ask this committee if they can refer to a single structure where such means have been employed and satisfactory results secured.

In Chapter III, Section 2, Paragraph (*a*), under "Fine Aggregate," page 216, the report reads:

> "Fine aggregate should always be tested for strength. It should be of such quality that mortar composed of one part Portland cement and three parts fine aggregate by weight when made into briquettes, prisms or cylinders will show a tensile or compressive strength, at an age of not less than 7 days, at least equal to the strength of 1 : 3 mortar of the same consistency made with the same cement and standard Ottawa sand."

Members of this committee are, I am sure, in touch with work being done by Committee C-1 on Cement, and Committee C-9 on Concrete and Concrete Aggregates, which show conclusively that this is not a correct statement. Many sands which do not show the strength in 1 : 3 mortar equal to that obtained by standard Ottawa sand in the same mixture, are very satisfactory; in fact a sand which shows lower strength may be more satisfactory than one which shows higher strength, provided the other aggregates and conditions are proper. Then the report goes on to state:

> "If the aggregate be of poorer quality, the proportion of cement should be increased to secure the desired strength."

In other words, the committee recommends that if the sand under consideration has only 70 per cent of the strength of standard Ottawa sand, the cement content of the concrete mixture must be increased or the strength will be inferior. This is an incorrect statement. Then, in the next sentence, the report states:

> "If the strength developed by the aggregate in the 1 : 3 mortar is less than 70 per cent of the strength of the Ottawa-sand mortar, the material should be rejected."

Mr. Wig. This also is not a correct statement, because there are materials that show less strength in mortar than 70 per cent of Ottawa sand which are wholly satisfactory in concrete, and the application of this requirement may mean a loss of thousands of dollars where other sand must be imported.

In Chapter VI, Section 3, under "Fireproofing," page 225, no reference is found to the fact that the character of the aggregate used in making the concrete may have an important bearing on its fire-resisting properties.

There are many other sections in this report which are incomplete or loosely drawn and should be changed, if it is to be a treatise on recommended practice. The failure of concrete structures is becoming more and more frequent due to lack of care and consideration of elements that are not treated by the report of this committee, which is recommended to engineers as representing the latest word in concrete design. Thus, under Section 4 of the same chapter, on "Waterproofing," we find no reference to the plaster method of waterproofing, which is one of the most common and satisfactory methods.

It is the speaker's opinion that the report should be referred back to the committee and not circulated as an approved report of this Society. I would therefore move as an amendment that the report be referred back to the committee. [Amendment seconded.]

Mr. Humphrey. MR. HUMPHREY.—It seems to me that that amendment is not one to which this Society should agree. It may be that the members of this Society take exception to the statements in the Joint Committee's report. That is very proper, and I think that all the discussions should be published with the report and should be referred to Committee C-2 for its future consideration. But the report presented is a Joint Report of your committee in collaboration with similar committees of other societies. This Joint Committee is not now in existence, and surely the committee of this Society would have no right to modify the Joint Committee's report. If the invitation of your committee should be accepted and our colleagues on the Joint Committee should be reappointed, then these criticisms might properly go back to that committee for further consideration; but whatever objection members of this Society may have to

Mr. Humphrey. this report it is not changeable by the Joint Committee because that committee is no longer in existence. We do not adopt or reject, but simply receive and print this report for information, as the American Society of Civil Engineers, the American Railway Engineering Association and the American Concrete Institute have done.

I hope this amendment will not prevail because I think there is in it an element of discourtesy. When you create a joint committee and it presents its report and goes out of existence, you cannot very well ask it to change something in its report.

Mr. Ashton. Mr. Ernest Ashton.—In seconding Mr. Wig's amendment, I had in mind that his criticisms directly refer to the paragraphs contained in Chapters II to VI, inclusive, expecting to further make a motion that these matters should then be referred to various committees of the Society; thus, that the paragraphs on "Aggregate" be referred to Committee C-9 on Concrete and Concrete Aggregates, which has that work in charge. I have no objections to printing Chapters VII to X, inclusive, which have to do directly with Design, etc.; but as long as we have committees in this Society that are investigating the matter of Aggregates, Waterproofing, etc., these matters should be referred to those committees. If we publish this report, it will be taken as representing the A. S. T. M. methods, designs and standards, whereas the report of our other committees may not be in conformity with this.

Mr. Humphrey. Mr. Humphrey.—I think there is some little difference. This Joint Committee report, as I see it, is in the nature of a paper presented before this Society; it does not purport to present the standards of this Society. The discussion of the report can properly be printed with it, but it cannot be altered or amended. As to the composition of the Joint Committee: the chairman of Committee C-9 is a member and there are other members who are members of the various committees of this Society that have been referred to. It seems to me that you cannot accept half of this report and not accept the other half. I do not see that there is any course open except to receive and print this report and then instruct Committee C-2 on Reinforced Concrete of this Society to do whatever you wish it to do.

Mr. Ashton. MR. ASHTON.—The title cover of the report is "Report of Committee C-2 on Reinforced Concrete." In the face of this title given by the Society, the report will not be considered as an ordinary paper. It is the definite report of a committee, and that committee I feel has overlapped to the extent of covering aggregates, waterproofing and other matters that are germane and pertinent to other committees.

The Chairman. THE CHAIRMAN (MR. W. K. HATT).—If the Chair may be allowed to say a word, it is that he understands that this report is not the final word in Concrete and Reinforced Concrete; what is complete this week may be changed next week, and it seems impracticable to bring this report up to date at this meeting and to add to it the results of the latest investigations, which come out month by month. I think Mr. Humphrey is right in saying that we must accept this report as a whole or reject it, because of our relations with other societies.

Mr. Thompson. MR. SANFORD E. THOMPSON.—In my opinion this amendment should not prevail. The various points taken up by Mr. Wig refer to specific sections which, from the nature of this report, are treated in a more or less general manner, partly because these features will be taken up in detail by the various committees of this Society.

Referring to fine aggregates, strictly speaking the combination of coarse and fine aggregates should be taken into account in selecting sand for concrete. At the same time, there is as yet no definitely formulated method of determining the values of sand other than that presented which would prohibit the use of a poor sand. We find structure after structure that is failing because of the use of poor sand, sometimes after several years of use, and it seemed to the committee absolutely necessary that definite recommendations should be presented which would tend to prevent some of these failures, even if they did throw out some sands that with certain coarse aggregates would make satisfactory concrete.

Although not bearing directly on the motion we are discussing, the age of test criticised by Mr. Enright may be referred to. The recommendation, rather indefinite, of not less than 7 days, has been considered quite carefully. It is impracticable to require a 28-day test of sand. In most buildings, the structure would be well under way before the end of the 28-day period. At the same time, this does give the contractor or builder the permission to test the sand in advance and wait for the 28-day test if he desires to do so. In practice we have found that a 3-day test is usually sufficient to obtain the quality of the sand, and commercially we test all sand at the age of 3 days and report upon it with the provision that if it does not meet the requirements it should be held for the 7-day test. **Mr. Thompson.**

Mr. W. M. Kinney.—It seems to me that this amendment should not prevail. It must be granted that at any time in the progress of the making of a report on such a broad subject as this, new things, new ideas, will come up that will tend to alter the report. Mr. Wig has had the privilege and opportunity of inspecting sea-water work a little more recently, probably, than any of the rest of us. The results of his studies may change our attitude toward the use of concrete in certain structures; but to reject this report which was written some time ago, just because we happen to have found out a little more about certain uses of concrete, would be out of order. **Mr. Kinney.**

Mr. J. M. Goodell.—If this report were one from a committee of this Society alone, it might be wise to try to suppress part of it in this manner, but it is already a public document issued by other technical societies. It has been widely read and quite widely used. No good can be accomplished by refusing to print part of it in our Proceedings now, while harm may be done to reinforced-concrete construction by such action, by an implication that its use is unwise for a wide variety of purposes for which it is entirely suitable. There may be, from what has been said, features of this report which might be modified to advantage in the light of recent experience. Nevertheless the only proper way to handle this report without injuring reinforced concrete unnecessarily is simply to print it as it has been submitted by a joint committee of several national societies, and then request the Secretary to indicate by footnotes that there are certain features still under consideration by a committee of this Society. **Mr. Goodell.**

This Society cannot modify anything that the American Society of Civil Engineers does; it cannot by any possibility in any way affect the stamp of approval that the American Society of Civil Engineers has put on the report. Nor can this Society

Mr. Goodell. in any way prevent the public from knowing that the American Railway Engineering Association, one of the most active and influential technical associations in this country to-day, has accepted this report. The American Concrete Institute has also adopted and circulated the report. Consequently nothing can be accomplished by not following the recommendation of this Society's members on the Joint Committee to print the report, with a notice of some suitable nature that there are certain sections which later knowledge has led committees of this Society to wish to investigate further.

Mr. Bates. MR. P. H. BATES.—I have heard this same appeal in regard to the reports of joint committees made before in these meetings. This Society is requested to adopt the report of the Joint Committee solely because one or more of the various organizations, represented by the Joint Committee, have adopted the report in question. While in this particular case I favor accepting the report, I am not doing so because it has been accepted by any other society cooperating with ours. The report should be discussed and treated on its merits, in the same manner as reports presented by other committees of the Society.

Mr. Wig. MR. WIG.—It is a very serious matter for this Society to put its stamp of approval upon statements that are known to be incorrect. The committee could have found, if they had searched for them, data proving the incorrectness of the statements. There was a report issued in England three years ago showing that disintegration has been occurring, owing to the corrosion of the metal. The report of this committee, if accepted, will be reprinted in many of our text-books. It will also be circulated as a reprint without any discussion. It will be adopted by engineers generally because it is signed by some of the most prominent engineers in this country on concrete construction and design, and it is little short of criminal to permit it to issue containing certain of these clauses which mean sure failure.

I desire to amend my amendment, to the effect that only Chapters II to VI, inclusive, of the report be referred back to Committee C-2, and that such portions of these chapters as are now under consideration by other committees of the Society be referred to such committees for their consideration. [Amendment seconded.]

MR. HUMPHREY.—There seems to be some misapprehension as to the nature of this Joint Committee's report and the original motion. As I understand the word "acceptance," it does not necessarily carry an endorsement by the Society. In other words, the acceptance of this report by the American Society of Civil Engineers did not mean that that Society as a whole had adopted it; it meant that it had been accepted for publication in its Proceedings. **Mr. Humphrey.**

Mr. Wig speaks about a lot of errors in the report. To take up and answer the various points that he has raised would involve endless discussion. There is a difference of opinion in the very committee to which he refers; its members are not in accord themselves. The very things he criticises are in process of evolution. Many of his statements are not sustained by the evidence. For instance, he criticises the paragraphs on electrolysis; the Bureau of Standards has conducted investigations on electrolysis and the physicist in charge of that work has approved these paragraphs on electrolysis. Mr. Wig takes exception to the report on the ground that the Joint Committee was not in accord; to agree on any report you must give and take, and the report agreed to represents the consensus of opinion at that time. That is all this report purports to do. Another joint committee in three or four years might radically change it, but this report represents the opinion of this committee as a body as to the value of the available data.

Briefly the Joint Committee has used its best judgment in formulating, from such data as were accessible, the state of this art at the present time.

MR. THOMAS NOLAN.—I represent officially the American Institute of Architects. It seems to me that some of the statements made in this discussion are of great importance to the architectural professions. The American Institute of Architects, with other members of this Society, can reasonably ask, in view of these apparent disagreements between some of the findings of the Joint Committee and the results of some of the investigations of the United States Bureau of Standards, represented in this instance by Mr. Wig, what the architects and engineers are to understand as the facts in the premises. The statements just made by Mr. Wig are very positive that some of **Mr. Nolan.**

Mr. Nolan. the conclusions embodied in this report are misleading. These are serious statements to make in regard to a committee report. It happens that the Bureau of Standards is not represented on the Joint Committee. I think that architects, who look to this Society and to its standards for guidance and who also have confidence in the work of the Bureau of Standards, would consider unfortunate a marked disagreement in regard to matters of fact relating to such an important material as reinforced concrete, and embodied in a report about to be printed and considered as the last word of this Society in regard to this material. Of course the report of the committee can be accepted; but it must be borne in mind that if it is published as the Final Report of the Joint Committee, and if it is found that some of its conclusions or recommendations do not agree with the results of some of the recent investigations of the Bureau of Standards, architects and others will naturally ask which conclusions they are to accept, because they look to both of these bodies of recognized authority for guidance in matters relating to standard tests and specifications.

The Chairman. THE CHAIRMAN.—This report has been printed already as a public document, printed and widely circulated. I might say also that as to the action of the American Concrete Institute, a committee of the Institute did not agree at all with certain of the findings of this report. The report was received and printed, but it is not to be sent to letter ballot; it has not become a standard of the American Concrete Institute. Neither will it become a standard of the American Society for Testing Materials, since it will not be referred to a letter ballot of the Society.

Mr. Talbot. MR. A. N. TALBOT.—I am not a member of Committee C-2, though I was a member of the Joint Committee. I think we should take account of the situation with respect to this as a joint committee. I do not see that referring the report back to Committee C-2 would be of value, for the Joint Committee has gone out of existence, and no action could be taken by it. It would merely be the same as tabling the report of the committee. If that is what is wanted, why not say that it is the purpose to get rid of it by laying it upon the table?

It is worth keeping in mind that this report was completed just a year ago. The material which Mr. Wig refers to concerning structures in sea water and their condition was not

Mr. Talbot.

available for the committee. I believe most of Mr. Wig's investigations were made after that time. It cannot be expected, therefore, that the report of a committee of this kind will include material which is even yet not made public. It seems to me also that Mr. Wig must have misspoken in some respects concerning the importance of some of the other items. The matter in the report concerning electrolysis seems to be practically as he says it should be. The principal other matter referred to is the test of sand. Mr. Wig may have some satisfactory strength test of sand available at the present time other than what is given in the report. An excellent test for impurities in sand has been developed since the committee finished its report. The report of the committee gives, I think, a very fair working method of determining the strength quality of sand. It is to be hoped that a better one will be available in the near future.

While this is a final report of a committee, I hope no one will consider that it purports to be a final report on the question of concrete and reinforced concrete. The members of the committee know that not only in the portions which have been criticised, but also in other parts of the report, in matters relating to design, in matters relating to stresses, modifications must be made with further knowledge concerning construction and the action of structures. With better knowledge of the way in which to make concrete, certainly within a few years there will need be great modifications made in various parts of this report.

Mr. Humphrey.

MR. HUMPHREY.—Your committee submitted a report transmitting in the following language the Joint Committee report:

> "Committee C-2 on Reinforced Concrete herewith submits the Final Report of the Joint Committee on Concrete and Reinforced Concrete, which is the result of the joint efforts of its own members and of the representatives of other societies appointed for the same purpose."

It seems to me that a motion is not in order that proposes to accept one portion and reject the other in a report of the character of this report of the Joint Committee. This Society, in accepting the report of the Joint Committee, does not adopt that report; in any event, it could not be its standard. Therefore, the report in its entirety must be printed as information, or not at all.

Mr. Thompson. MR. THOMPSON.—Mr. Wig has made sweeping criticisms of the report and answers to these should be placed on record. The principal points referred to by him are corrosion of metal, sea-water action, and electrolysis. Now in Chapter II, Section 4 (*a*), page 212, the statement is made that "Tests and experience indicate that steel sufficiently embedded in good concrete is well protected against corrosion." In Section 4 (*c*) under "Sea-Water," page 213, the character of concrete is referred to, and while the report does not go so far as Mr. Wig would wish in prohibiting concrete from sea-water use, it does state, in the opening sentence: "The data available concerning the effect of sea water on concrete or reinforced concrete are limited and inconclusive." It certainly is evident that if concrete is laid which in itself will not resist sea water, the steel may not be protected.

In Section 4 (*b*), under "Electrolysis," the opening sentence refers to reinforced-concrete structures, and what follows is intended by the committee to refer to reinforced-concrete structures. If Mr. Wig makes it read in some other way, it hardly can be said to reflect upon the value of the report.

Mr. Wig. MR. WIG.—The speaker's criticism of this report should not be misunderstood as a general condemnation of concrete, for in most cases concrete can be so designed and constructed as to prove satisfactory; but such may not occur if the recommendations of this committee are followed. While the statements made relative to corrosion of steel are partly based upon an investigation recently made by Mr. L. R. Ferguson and the speaker, such corrosion has been observed for several years and reported upon in technical journals as well as in the Proceedings of the Institute of Civil Engineers of Great Britain, all of which data were available to the committee.

The speaker's criticism of the committee's statement under "Electrolysis" is relatively unimportant, although it might be misunderstood by some as referring to plain concrete. There are two other very important matters that have been overlooked by previous speakers; in fact, these are almost as important as the question of corrosion of embedded metal. In Chapter II, Section 4 (*d*) on "Acids," page 214, the report reads:

> "Dense concrete thoroughly hardened is affected appreciably only by acids which seriously injure other materials. Substances like manure that

contain acids may injuriously affect green concrete, but do not affect concrete that is thoroughly hardened." **Mr. Wig.**

This statement is incorrect, and there are appreciable data available to prove its incorrectness. Furthermore, in Section 4 (*f*) on "Alkalies," page 214, the statement made by the committee is an incorrect one. There are no structures where any such attempt at the protection of the concrete has been tried, that it has been a success to the knowledge of the speaker, who is closely in touch with the conditions in alkali regions.

The burden of proof for the statements made in this report is on the committee and the responsibility is great; particularly if the recommendations made, when followed by the engineer, may result in total failure or disintegration causing the loss of thousands of dollars.

Mr. Slater. MR. W. A. SLATER.—Different views have been expressed; some that the report should be accepted; some that it should be printed and at the same time, that if it is printed, it will set the stamp of approval of the Society on the report. Can we not obtain the advantage of putting the report out for further discussion and at the same time of showing courtesy to the Joint Committee, by printing the report and at its close the discussion submitted, together with footnotes at the bottom of each page pointing to clauses which are discussed? That will give no chance for the report to be misleading and it will give every one an opportunity to present criticism together with data supporting their critisism, and will make the publication of the report a real contribution to the literature on the subject.

Mr. Kinney. MR. KINNEY.—Apparently it is not Mr. Wig's intention to raise the question that concrete is not adaptable for sea water and other special work, but he wants something in the report to indicate the proper method of designing and handling concrete so that the destructive agencies encountered can be prevented from doing their work. It is not apparent how failure to print this report is going to accomplish his object. It would be quite proper if the Bureau of Standards or Mr. Wig can at this time suggest means of avoiding this trouble, to add these suggestions as discussion of the report. No doubt the remarks made by Mr. Wig come as a result of very careful study. I believe it is his intention to recommend corrective measures, and

Mr. Kinney. that is what we really want. I do not agree with the previous speaker that these remarks should be referred to by footnotes, as that is a method of treatment that has never been adopted, and there is no reason why it should be adopted in this case.

The Chairman. THE CHAIRMAN.—If there is no further discussion, the Chair will call for a vote on the amendment by Mr. Wig. [The amendment was lost.]

The amendment is lost. The Chair will now call for a vote on the original motion by Mr. Humphrey, that the report of the Joint Committee be received and printed. It is of course to be understood that the discussion of the report will also be printed in the Proceedings. [Mr. Humphrey's motion was carried.]

Mr. Talbot. MR. TALBOT.—Before we pass to the next report, I should like to second the suggestion made by Mr. Kinney, and put it in the form of a motion requesting Mr. Wig, in making up his discussion, to describe fully the methods of making concrete which will avoid the troubles he refers to. His criticism has been sweeping, a rather blanket denunciation, and it may carry meaning beyond what he intends. At any rate, it will be helpful to have something constructive. [Motion seconded and carried.]

Mr. Wig. MR. R. J. WIG (*by letter*).—Complying with the resolution of Mr. A. N. Talbot the following additional remarks are presented relative to the Final Report of the Joint Committee on Concrete and Reinforced Concrete. The statements made below on reinforced concrete were prepared jointly by Mr. L. R. Ferguson and the writer.[1]

"*Reinforced Concrete Failing.*—The majority of all reinforced-concrete marine structures on the American Coasts subjected to sea-water action are now showing evidences of deterioration or failure due to the corrosion of the embedded reinforcement. Some of these structures are not a year old and the oldest is but ten years. The older structures show advanced signs of deterioration and many not over four years old are badly affected, while one reinforced-concrete pleasure pier, opened to the public July, 1916, was found to be seriously affected by October of the same year. In that short time the reinforcing had corroded to such an extent that spalling of the concrete had begun. A number of reinforced-concrete structures were found which were not cracked or deteriorated. Most of these were not over two or three years old. One, however, was ten years old. **Mr. Wig.**

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[1] The paragraphs of Mr. Wig's discussion placed in quotation marks appear in the third of five articles by Mr. Wig and Mr. L. R. Ferguson under the title "Reinforced Concrete in Sea Water Fails from Corroded Steel," published in the *Engineering News-Record*, October 11, 1917, p. 689.

"Undoubtedly the most important information gained during the recent investigation made by Mr. L. R. Ferguson and the writer was the true condition of reinforced concrete structures subjected to the action of sea water and the cause of the trouble. There have been a number of reports and articles in the technical press describing marine structures of reinforced concrete which have shown signs of deterioration, but as far as is known no one has developed the real conditions. Some plausible explanation has always been made which has accorded with the existing theory that reinforcing is amply protected against corrosion when embedded to a depth of one or two inches in concrete of good quality. These articles have described structures in widely separated localities, so it is evident the same forces are at work wherever there is sea water and the trouble is not confined to any particular part of the world. The effect, however, is much more pronounced in some localities than in others and certain conditions greatly accelerate the action. Some of the reinforced-concrete structures show only slight signs of deterioration after six or seven years exposure, while others are practically failures within four years of the time they were built.

"*Corrosion Occurs in Good Concrete.*—Usually the corrosion of reinforcing is attributed to the poor quality of the concrete. Porous concrete does, of course, offer less protection to the embedded metal and corrosion will be more rapid in such cases. Reinforcing will, however, corrode under certain exposure conditions in a few years even when the concrete is of excellent quality. There is a reinforced-concrete quay wall or wharf on the south Atlantic coast which was built in 1912 which illustrates this. The design consists of precast reinforced-concrete piles supporting a reinforced-concrete deck. The concrete for the piles was proportioned of 1:1½:3 (cement, sand and stone) mixed wet so that the rods were thoroughly coated. The ingredients were of excellent quality and the concrete was mixed and placed as well if not better than is the usual practice. When this

Mr. Wig. wharf was examined last fall (1916) it was found that 60 per cent of the piles were cracked at the corners and in many cases the reinforcing was exposed. There is another pier along the Atlantic coast built ten years ago which consists of precast concrete piles, but here a wood deck was used. The concrete for the piles was of good quality, proportioned 1:2:4 (cement, sand and stone). In this pier there are about 2500 piles and practically every one is cracked or spalled. Fig. 1 shows some of the piles.

"*Deterioration Common to All Localities.*—In the Philippine Islands many of the reinforced structures have cracked to such an extent, due to the corrosion of the metal, that they have caused serious apprehension. The explanation advanced by Mr. J. L. Harrison, District Engineer, Lloilo, P. I., in an article in *Concrete*, March, 1917, is that the trouble is caused by the use of sea water in mixing the concrete. Mr. Harrison came to this conclusion largely by analyzing specimens of concrete which had cracked and in these he found an appreciable amount of chlorine. He was on the right track; but the chlorine did not come necessarily from the salt in the water used in mixing the concrete

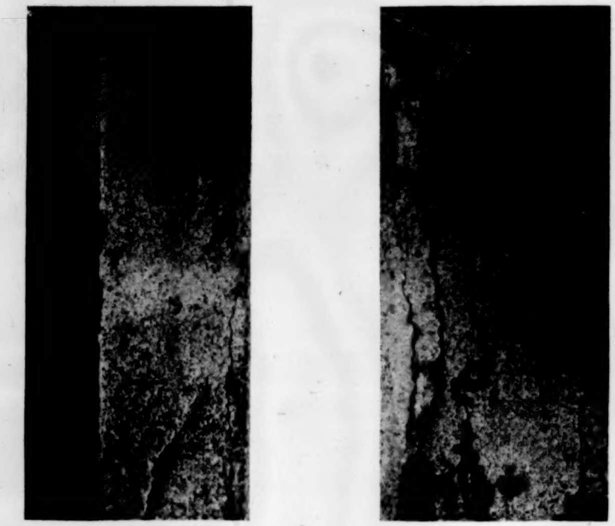

FIG. 1.—Showing Typical Cracking and Spalling of Concrete Pile Caused by Corrosion of Reinforcement.

and moreover the conditions he observed would without doubt **Mr. Wig.** have occurred had the concrete been gaged with fresh water. He is also in error in assuming 'that on the whole the conditions in the Philippine Islands are so different from those which prevail in temperate climates that the results there (in the United States) obtained are not a reasonable criterion of what must be expected here.'

"Exactly the same phenomena are occurring in America, and in fact, everywhere that concrete is exposed to sea water. Under warm humid conditions the action is much more severe and rapid, but the destructive action is in progress more or less rapidly everywhere. That the gaging of the concrete with sea water or the use of aggregate impregnated with salt water is not the primary or underlying cause of the corrosion of the embedded reinforcing is shown by the fact that in many of the structures examined the concrete was mixed with fresh water and the aggregates were free from contact with salt water. This was true of the two piers first referred to where very extensive cracking has occurred. During the investigation one of the matters given particular attention was the possible use of salt water in gaging the concrete, and the statement can be made with assurance that the prevailing corrosion of metal embedded in concrete cannot be attributed to the use of sea water in mixing, for with few exceptions American structures have been built with fresh water.

"*Rods Embedded 2½ in. Corrode.*—It has been suggested that close proximity of the reinforcing rods to the surface has produced corrosion. In an article in ***Engineering Record*** of January 25, 1908, page 105, there is a description of a reinforced-concrete building which was torn down six years after erection. Here it was found that corrosion of the reinforcing had occurred in the columns where the hoops were closer than ¾ in. to the surface and the necessity of keeping the steel "at least ¾ in. from the surface" is pointed out. In passing it might be noted that the difference between ¾ in. and 1 in. of covering which the Joint Committee recommends as giving perfect protection against corrosion is a very small margin of safety. As a matter of fact, however, neither ¾ in., 1 in., or, in many cases, even 3 in. of concrete will ensure the embedded,

Mr. Wig. reinforcing against corrosion in marine structures. In a number of the piles of the pier previously mentioned where the concrete was proportioned 1:1½:3; it was observed that some of the rods which had spalled off the concrete were embedded 2½ in. and were badly corroded, and in many other structures where advanced corrosion of the reinforcing was found the metal was embedded over 2 in. When the metal is near the surface it will corrode much more rapidly than when embedded to a greater depth, but the thickness of covering must be much more than has been commonly supposed.

"*Electrolysis not the Cause.*—Perhaps the most popular theory of the cause of corrosion of metal embedded in concrete is that of electrolysis. A few years ago this was the explanation advanced for practically all the ills of reinforced concrete and in some cases it was made to apply to plain concrete also. Naturally the corrosion of reinforcing in marine structures was attributed to this cause and a number of cases were diagnosed as electrolysis with little more than a superficial examination. In other cases the examination has been carefully made, but lack of any better explanation than that of electrolysis and the firmly fixed idea that 1 or 2 in. of concrete thoroughly protects the reinforcing from corrosion, have led the investigators to adopt this theory.

"This seems to have been the case in the Second Report of the Committee on Reinforced Concrete of the British Institution of Civil Engineers. This report contains descriptions of a number of reinforced-concrete structures subject to sea-water action. Most of these show extensive cracking of the concrete along the lines of the reinforcing rods. The suggestion is made that the trouble arises from several causes—closeness of metal to the surface, improper placing of concrete causing porous sections and lack of bond along the plane of reinforcing; but if there is electric current near the structure it is made to take a large part of the responsibility for the failure.

"There probably have been some instances where electrolytic action caused the corrosion of reinforcement in marine concrete structures, but such cases are very infrequent and the effect from this action is different in one very marked particular from that which is occurring in practically all reinforced concrete in sea water which is deteriorating.

"The cracking of the concrete always starts *above the high water line,* although it may extend a little below this point as corrosion develops. Very seldom is it found to go down as far as the elevation of low water and then only when the reinforcing is deeply embedded so that the spalling effect extends a considerable distance below where the metal is affected. This condition was also noted in the report of the British Institution and it effectually disposes of the electrolytic theory. In all the experiments made to determine the action of electric current on reinforced concrete it has been found that cracking due to the corrosion of the reinforcing starts where the current leaves the rods. Therefore, if electrolysis were the cause the corrosion and cracking must occur below the elevation of high water where the current leaves the metal. In a reinforced-concrete marine structure in which the corrosion and deterioration do not extend below the water line electrolysis can not possibly be the cause. For this reason also the corrosion of the reinforcing referred to in the report of the British Institution cannot be caused by electrolysis for it is stated that the cracking of the concrete occurs above the level of high water. **Mr. Wig.**

"At Long Beach, California, a large number of reinforced concrete piles were cast in 1911, the intention being to use them in constructing a pier. After the piles were cast the work was stopped. The concrete piles have remained where they were cast, about fifty feet from the shore, without covering and without any electric current near them. The tide never rises high enough to reach the piles and so they are constantly dry except from such wetting as they get during the rainy season. Evidently the piles were molded in two operations, one set being of a little better quality apparently because of the use of a somewhat drier consistency of concrete. Practically every one of the set made from the very wet concrete has cracked. Certainly electrolysis cannot possibly be the cause of the corrosion of the reinforcing rods. Fresh water was used in mixing the concrete.

"Another very good illustration that corrosion of reinforcing with resultant cracking of the concrete is not due to electrolysis was found in one of the rivers emptying into the Atlantic Ocean. At the mouth of the river there is practically undiluted sea water. About 15 miles from the mouth the water is just per-

Mr. Wig. ceptibly brackish and 10 miles further up the river the water is fresh. In this river there are over 25 beacon lights and these extend from the mouth to a point beyond where the fresh water is always found. The supports for these lights consist of four precast reinforced-concrete piles supporting a reinforced-concrete slab deck to which is attached the superstructure consisting of steel members or pipes in the form of a tower. This supports the beacon light. All of these lights burn gas or oil and none of them are operated by electricity, nor is there any electric current near them. In all cases the deck slab is at least 6 ft. above the high-water line and in a number of the structures it is 10 or 12 ft. above that point. Knee braces were used frequently to stiffen the slab. A very careful examination of these structures showed that not one of those situated in fresh water was cracked or deteriorated. Holes drilled through the concrete into the reinforcement proved that no corrosion whatever had occured. On the other hand every structure below the point where brackishness of the water could be detected was cracked from the corrosion of the reinforcing, the action being markedly more severe as the salt content of the water increased. All of these structures were built about the same time, during 1912 and 1913 by the same contractor. The same materials were used for the concrete for all the structures and it was of excellent quality. It might be mentioned also that fresh water was used in gaging the concrete. All the cracking was above the water line and in many of the structures the deck slab and knee braces are the most affected.

"*Causes of Corrosion.*—Undoubtedly the real cause of the trouble is the accumulation of sea salts in the pores of the concrete above the water line by capillarity and evaporation and the absorption by the concrete of air carrying very minute particles of sea water. Moisture in this form is transported by the wind a much greater distance than is usually believed. This is shown by the presence of chlorine in the form of sodium chloride. If the moisture from the sea were simply in the form of water vapor from evaporation there would be no salt found in the atmosphere. The studies made on this subject by the United States Geological Survey indicate that moisture from the ocean is carried by the air many miles inland. This probably accounts for the sodium chloride Mr. Harrison found in concrete in the Philippine Islands. **Mr. Wig.**

"Chlorine and oxygen together form a very active corroding agent. Of course this has long been known, but what we did not before appreciate was the fact that the salt air could penetrate concrete to anything like the depth it really does.

"When steel corrodes it occupies about twice its previous volume. The expansive force thus developed by metal embedded in concrete is enormous and the concrete is soon stressed sufficiently to cause cracking.

"*Corrosion Causes Cracking.*—The question has been raised as to whether the cracking comes first and the corrosion is a secondary action which in turn further develops the cracking, or whether the primary cause of the trouble is the corrosion of the reinforcing with cracking as a secondary action. A number of conditions were observed which seem to furnish conclusive evidence that the reinforcing corrodes first and this causes the concrete to crack. The cracking is always along the lines of reinforcing and very frequently no other cracks could be found in the member. It seems probable that if cracking had started first it would be more widely distributed. Usually when a pile is affected all four corners tend to spall, and if one pile in a structure is cracked many others will be found in a similar condition and the beams and slabs—if of reinforced concrete—will also be cracked. It is conceivable that in removing the forms from a pile, if the concrete is green a corner may be slightly cracked; but it is not probable that all four corners would be cracked and it is still less probable that such careless work should be done throughout the structure. As a matter of fact most of the structures which were examined and found cracked were built by competent, experienced contractors under rigid inspection. During the construction of one of the piers referred to in the early part of this discussion, in which cracking has been very extensive, the writer had an opportunity personally to observe the work. It was done quite as well as, if not better than, is usually the case; in fact, the firm who had the contract is noted for the excellent quality of their work.

"It has been suggested that the cracks in concrete piles are caused by shattering of the head during driving. This cannot

Mr. Wig. be the case, for most frequently the cracking does not extend to the top of the pile and many of the piles observed were jetted into place.

"There is one pier in the southern Atlantic which is supported on Brackston piles. These piles are made with a heavy cast-iron shoe at the bottom which projects beyond the shaft of the pile. The pile is driven by means of a sleeve which is threaded over the concrete and rests on the shoe so that the driving is done on the shoe and not on the concrete. A number of piles in this wharf are cracked over the reinforcement. Of course the cracking of beams and slabs cannot possibly be accounted for in this way. If the cracking is the first action which takes place it is most probable that some indication of this action would have been observed in the beacons previously referred to which are situated in fresh water. As was stated before no evidence of cracks in the concrete could be observed in these. In most cases the cracking stops at the high-water line or a little below it. This is a striking characteristic of the phenomenon. It is inconceivable that if the cracks occurred first they would always be in the same place. The supposition that the corrosion of the metal is originally caused by cracks in the concrete must be dismissed. The metal first corrodes and then the concrete cracks.

"It is very significant that the cracking does not extend below the high-water line. The reason for this is probably because the air does not as readily penetrate the concrete below this point and a concentration of sea salts cannot be obtained.

"*Methods of Preventing Deterioration.*—Just how to overcome the widespread deterioration of reinforced concrete caused by the corrosion of the embedded metal is a difficult problem and the exact treatment and method to be followed will depend upon the exposure conditions, design and location of the structure. The use of smaller diameter rods seems to have a beneficial effect. Increasing the distance of the reinforcing from the surface also assists greatly the resistance to corrosion. In precast piles the added weight due to increasing the covering of concrete over the reinforcing must be considered. In many cases the stresses due to bending after the pile is in position are not great above the water line. This condition may be taken advantage of in designing concrete piles for marine structures. For instance, the vertical reinforcing may be bent in toward the center at a point **Mr. Wig.** a little below the water line. Usually ample strength in flexure can be provided by care in design and the vertical bearing strength of the pile will be but slightly diminished. In many concrete structures the members are considerably over-reinforced; this is especially true of piles. Every effort should be made to diminish the amount of reinforcing and if at all possible a design should be adopted which eliminates the metal entirely for the work above water. Perhaps gravity sections and massive work will cost more in the first place, but the additional expenditure will ultimately prove an economy unless special precautions are taken to ensure the reinforcing against corrosion. Frequently a combination of reinforced concrete below the water line with plain section above will prove best. If the reinforcing is made non-corrosive by galvanizing in the vulnerable part of the structure—that is, above water—the destructive action of the moist air will be prevented or greatly lessened and the life of the structure materially increased. Painting or impregnating the exposed parts of a concrete structure will be at best only a temporary expedient unless better materials can be found than those now at hand.

"The proper methods to be pursued and the design to be adopted to prevent the deterioration of reinforced concrete subjected to sea-water action depend upon a number of conditions, such as the type of structure, its purpose, the severity of exposure and the climatic conditions. The latter consideration has considerable influence. In warm humid climates the corrosion of the reinforcing and the consequent cracking of the concrete proceeds much more rapidly than in cool climates where the amount of moisture in the atmosphere is less."

The above data are furnished as conclusive evidence that the Joint Committee is in error in its contention that one inch of concrete will protect reinforcement against corrosion if exposed to sea water.

Concrete is not Immune to Acid Attack.—The Joint Committee's statement that "Dense concrete thoroughly hardened is affected appreciably only by acids which seriously injure other materials," is, of course, very indefinite, but it would be inferred that cement or concrete would resist acid attack equally as well as clay products.

Mr. Wig. There are many cases on record of the disintegration of concrete by acid and it is common knowledge that if concrete is continuously exposed to even weak solutions of sulfuric acid it will completely disintegrate.

There have been cases reported of the disintegration of concrete by organic acids, but there has usually been an element of uncertainty as to the original quality of the concrete. Technologic Paper No. 95 of the Bureau of Standards, page 62, contains reference to the disintegration of concrete of known quality. Investigation indicates that similar disintegration is occurring in other localities in the eastern United States.

There is no way of preventing this disintegration so far as the writer is aware except by protecting the concrete from the acid solution by an impervious membrane.

No Known Method of Protecting Concrete from Alkali Action.—The Joint Committee's report states that "destructive action can be prevented by the use of a protective coating." The disintegration of concrete by alkali is caused primarily by the absorption of the solutions by capillarity and the evaporation of the water at the surface of the structure above the water line with the crystallization of salts in the pores, resulting in physical disruption followed by chemical deterioration. The only effect of a protective coating on the surface is to reduce the rate of evaporation, but it has not been found in any case to be effective in preventing disintegration. There is no known method of preventing such disintegration if alkali salts of certain character have access to any part of the structure.

Certain Aggregates are Unsatisfactory for Fireproofing Purposes.—Under fireproofing, the Committee should give warning against the use of certain aggregates which spall and explode with violence upon being heated, as noted in the Kentucky Public Elevator, Louisville, Ky., and by Prof. I. H. Woolson in the Far Rockaway Warehouse fire, and other cases. A simple test of suddenly heating a sample of the aggregate will determine its character in this respect.

Common Method of Waterproofing is by Cement Plaster.—The Joint Committee's report fails to mention one of the very common and most efficient methods of waterproofing, that is, the application of cement plaster to the inside or outside surface of the structure in one or more layers.

Committee C-2.

OFFICIAL CLOSURE BY LETTER ON THE PART OF COMMITTEE C-2.—Committee C-2 on Reinforced Concrete has no desire to discuss questions involving differences of opinion. The committee feels, however, that it should give the facts concerning certain statements that may be misleading.

Paragraph (*b*) Section 4, under Electrolysis, page 213, that is criticized by Mr. Wig, was approved by the physicist of the Bureau of Standards who was in charge of the Bureau's investigations of electrolysis, and only by an erroneous interpretation of the paragraph can it be applied to un-reinforced concrete. The paragraph relates to reinforced concrete, and the closing statement is that "non-reinforced concrete structures are practically immune from electrolysis troubles."

Mr. Wig's statement that the recommendations in the Section on Aggregates, page 215, are not in accord with the work of Committee C-9 on Concrete and Concrete Aggregates, is also unwarranted. The chairman of that committee was the chairman of the sub-committee of the Joint Committee which had the matter of aggregates under consideration, and other members of the Joint Committee were also members of Committee C-9, so that the recommendations of the Joint Committee were made with a due regard to the work of Committee C-9, which has in progress investigations of sands by various testing laboratories, with which the Bureau of Standards is cooperating. It has not completed this work nor has it presented any standard method of determining the value of exceptional sands. The Joint Committee has formulated general recommendations as affecting good practice.

Concerning Mr. Wig's reference to the Joint Committee's statement as to the effect of sea water on concrete, your committee would direct attention to the following abstract from Mr. Wig's discussion:

> "There have been a number of reports and articles in the technical press describing the marine structures of reinforced concrete which have shown signs of deterioration, but as far as is known no one has developed the real conditions."

The investigations to which Mr. Wig refers were undertaken largely during the past year, after the Joint Committee had

Committee C-2. made its report, which is dated July 1, 1916, and the results of these investigations have not yet been published by the Government. There also is not sufficient information in the series of articles not yet completed by Messrs. Wig and Ferguson, appearing in the *Engineering News-Record* (about fifteen months later than the date of the report and several months later than the discussion at the annual meeting of the Society), nor is there information yet available that would warrant changes in the report. The report does call attention to the importance of extreme care in making and placing concrete in sea water, and this cannot be emphasized too strongly. The discussion by Mr. Wig serves a useful purpose in pointing out by examples the dangers of improper use of concrete under such conditions.

Your committee would further call attention to the fact that the Joint Committee does not itself regard its report as "the last word on the subject," as is indicated by the following abstract from the last paragraph of Chapter I:

> "The Joint Committee has reached the conclusion that, with this effort to express the present state of the art, it would be desirable for it to withdraw from the field. This action has been taken in the hope that a work similar to that which the Committee has attempted to perform will again be undertaken within a reasonable term of years, in order that there may be some authoritative body to consider and pass upon newly acquired knowledge and information gleaned from experience."

Committee C-2 is still in existence and expects in due course to report on specifications for reinforced concrete, and will in the preparation of these give full consideration, not only to the results of the investigation by Messrs. Wig and Ferguson, but to any other information that may become available.

REPORT OF COMMITTEE C-4

ON

CLAY AND CEMENT SEWER PIPE.

In its report to the Society in 1916 the committee presented a compilation of its previous work in the form of an appendix entitled "Analytical Data for Sewer Pipe."[1] This compilation was the subject of extensive discussion by the committee during a number of meetings at Atlantic City in June, 1916, at which were present also some representatives of the clay and cement-concrete pipe industries.

Since the last annual meeting the officers of the committee have held ten meetings. Sub-committees have presented reports on the form of proposed specifications for clay and cement-concrete sewer pipe, on safe crushing strength of sewer pipe, and on the Tentative Recommended Practice for Laying Sewer Pipe (Serial Designation C 12-16 T) published as tentative last year.[2]

These reports were discussed, modified and approved at meetings of the committee held in New York on April 24 and 25, 1917.

The committee presents herewith the following:

Proposed Tentative Specifications for Clay Sewer Pipe;

Proposed Tentative Specifications for Cement-Concrete Sewer Pipe;

Proposed Revised Tentative Recommended Practice for Laying Sewer Pipe;

Proposed Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling.

It is recommended that these proposed standards be printed as tentative for one year before being presented to the Society for adoption.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 223 (1916).

[2] *Ibid.*, p. 472.

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 19 have voted affirmatively, 1 negatively, and none have refrained from voting.

Respectfully submitted on behalf of the committee,

RUDOLPH HERING,
Chairman.

E. J. FORT,
Secretary.

A. J. PROVOST, JR.,
Vice-Chairman.

EDITORIAL NOTE.

The three proposed tentative specifications and the proposed revised tentative recommended practice referred to in the report, were accepted for publication among the Tentative Standards of the Society, and appear on pages 634–660 and 701–703.

REPORT OF COMMITTEE C-5

ON

FIREPROOFING.

Committee C-5 on Fireproofing has held, during the past year, two conference meetings with various other technical societies for the purpose of classifying fire-resistive construction and standardizing methods of conducting fire tests.

The organizations represented at these Conferences were:

American Society for Testing Materials;
National Fire Protection Association;
U. S. Bureau of Standards;
National Board of Fire Underwriters;
Underwriters' Laboratories;
Associated Factory Mutual Fire Insurance Companies;
American Institute of Architects.
American Society of Mechanical Engineers;
American Society of Civil Engineers;
Canadian Society of Civil Engineers;
American Concrete Institute.

These Conferences originated in a joint action last year of Committee C-5 and the Committee on Fire-resistive Construction in the National Fire Protection Association. The membership of these two committees, together with the representatives of the organizations named, formed a group of qualified technical experts which included the majority of that class in this country.

These Conferences accomplished three important objects:

1. *Classification of Materials and Construction.*—An agreement that fire-resisting materials and construction should be classified into three or more grades based upon the degree of protection which they would afford when measured by a fire test conducted in accordance with a standard time-temperature curve. The classes were designated as those

which afford One-Hour Protection, Two-Hour Protection, Four-Hour Protection, etc. This classification harmonizes easily with the fire test work already done under the standard specifications of this Society, by the Underwriters' Laboratories, and by other investigators. It is also evident that it will be a simple matter to interpolate other classes as they may become necessary.

2. *Standard Time-Temperature Curve.*—The adoption of a tentative Standard Time-Temperature Curve to control the conduct of fire tests of materials and construction. The points on the curve which determine its character were selected by the Conference and are indicated on the plot of the curve shown in Fig. 1. It was also decided that the temperature fixed by the curve shall be deemed to be the average temperature given by the several thermo-couples (not less than three distributed over the surface of the test sample) and situated at distances of 6 in. from the surface of the test sample.

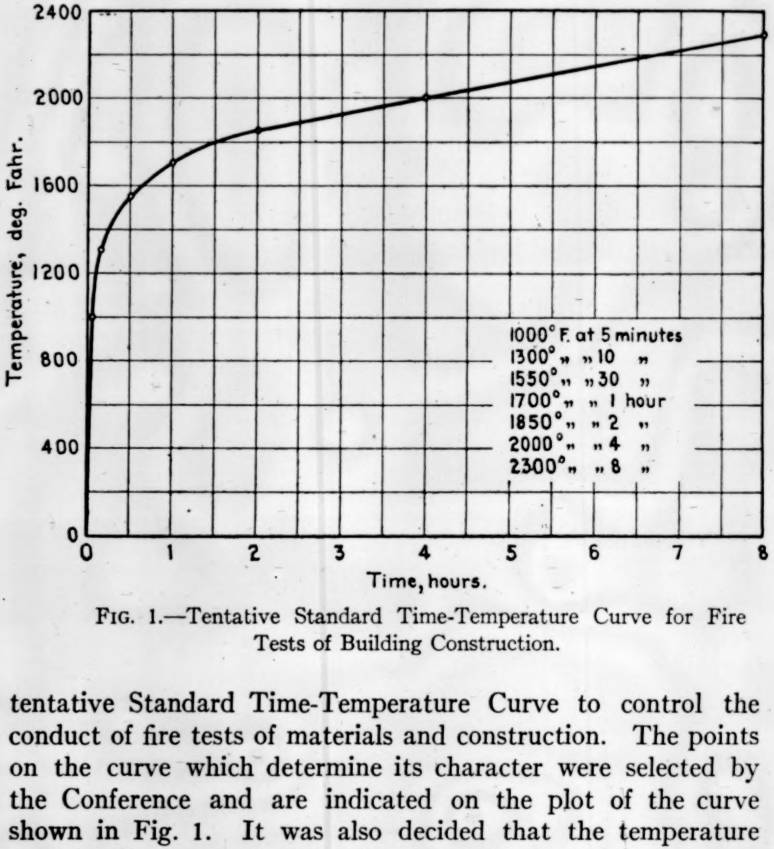

FIG. 1.—Tentative Standard Time-Temperature Curve for Fire Tests of Building Construction.

The Conference members purpose to secure data from practical application of the curve to tests, and later determine what changes, if any, may be desirable; also what the permissible temperature variations may be. When these have been decided upon, the curve will be presented to the Society for adoption as a standard. It will also be incorporated in a future revision of the present Standard Tests for Fireproof Floor Construction (C 2–08) and for Fireproof Partition Construction (C 3–09).[1] The committee would be pleased to have investigators use the curve, and offer suggestions as to its suitability for the purpose intended.

3. *Tentative Amendments to Existing Standards.*—The Conference further adopted the following details of specification governing the conduct of fire tests, and they are submitted by the committee as tentative amendments to the present Standard Tests for Fireproof Floor Construction and for Fireproof Partition Construction. The portions not applicable as amendments to the existing specifications shall be considered as new tentative specifications which will later be incorporated into specifications which will be drafted to include them.

TABLE I.

Parts of Structure.	Type of Protection.	Size of Hose Nozzle, in.	Water Pressure at Nozzle, lb.	Time of Application, min.
Floors and Roofs	1 hour	1⅛	50	2.5
	2 "	"	50	5
	4 "	"	50	10
Walls, Columns and Partitions	1 "	"	30	2.5
	2 "	"	30	3
	3 "	"	30	3
	4 "	"	50	5

DETAILS GOVERNING CONDUCT OF FIRE TESTS.

Periods for Test.

1. (*a*) The fixed periods for standard fire tests on floors, columns, walls, and roofs shall be established at 1, 2 and 4 hours respectively.

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[1] 1916 Book of A.S.T.M. Standards, pp. 487-492.

(*b*) The fixed periods for standard fire tests on partitions shall be established at 1, 2, 3 and 4 hours respectively.

(*c*) The fixed periods for standard fire tests on protection of wall openings shall be fixed at 1, 2 and 4 hours respectively.

Size of Partition. 2. In partition tests the area of the test sample shall be not less than 100 sq. ft., and no dimension less than 9 ft.

Application of Hose Stream. 3. (*a*) Fire tests upon structural members or constructions shall include the application of a hose stream at the termination of the fire test.

(*b*) The size of nozzle, water pressure, and time of water application shall be as indicated in Table I.

(*c*) In 4-hour tests on floors and roofs, the top of the test sample shall be flooded with water at low pressure for 3 minutes immediately after the expiration of the first 5 minutes' application to the underside. After the flooding, the stream shall again be directed against the underside at full pressure for 5 minutes. In the case of the 1 and 2-hour tests the flooding shall be done after the full application of the hose stream to the underside of the sample.

(*d*) In tests on walls, columns, and partitions, the distance of the nozzle from the test sample during application of water shall be 20 ft. when the hose stream is applied approximately normal to the surface of the test sample; and when applied in the standard A.S.T.M. test house for partitions, it shall be not more than 2 ft. from the door.

Load. 4. Floors shall carry during test a uniformly distributed load equal to that for which they are designed, and after the fire, the load shall be increased to four times the load carried during test.

Any suggestions or criticisms will be welcome, and should be sent to either the chairman or secretary of the committee.

This report has been submitted to letter ballot of the committee which consists of 11 members, of whom 10 have voted affirmatively, none negatively, and 1 has refrained from voting.

Respectfully submitted on behalf of the committee,

IRA H. WOOLSON,
Chairman.

RUDOLPH P. MILLER,
Secretary.

Editorial Note.

The tentative revisions in the Standard Tests for Fireproof Floor Construction and the Standard Tests for Fireproof Partition Construction referred to in this report were accepted for publication in the Proceedings.

The data in items Nos. 1 and 2 (pages 295–297) have been embodied in a tentative standard under the title "Tentative Method for Control of Fire Tests and Classification of Materials and Construction as Determined by Test"; see pages 679–680.

DISCUSSION.

Mr. Slater. MR. W. A. SLATER.—I think that the report of Committee C-5 represents a distinct advance in that a fire test of less than the extreme period of 4 hours is recognized as being of use for floors and partitions that are not subjected to the most severe conditions and for which not so much protection is required. The load requirements, however, are practically the same as the load requirements in the previous report. I am of the opinion that the load requirements are more severe than they ought to be when we compare them with the methods used for the design of floors. If a floor is designed for 150 lb. per sq. ft. live load and it has a weight of 50 lb. per sq. ft. itself, the total designed load is 200 lb. per sq. ft. and the accepted working steel stress for this load is 16,000 lb. per sq. in. The specifications require that four times the design live load be applied to the floor after it has been subjected to the fire test, giving 600 lb. per sq. ft. applied live load, and it already has its own dead load, so the floor will be subjected to 650 lb. per sq. ft. after it has been through the fire test. If the stress in the steel actually developed by the working load is 16,000 lb. per sq. in., then, under the applied load after the fire test has been made, we have $3\frac{1}{4}$ times 16,000 or 52,000 lb. per sq. in. It is evident that such a panel cannot meet the requirements unless either the tensile stress of 16,000 lb. per sq. in. is not developed by the design load, or the elastic limit of the steel is very high, either condition of which I do not believe it is the desire of the committee to impose as a requirement.

It is undoubtedly true that tests have been made which have met the requirements imposed, and yet it seems to me that it is in the nature of penalizing the shorter spans and lighter building materials to require that such a thing be done. In other words, we would not be designing rationally if we made specifications for fire tests which counted on the fact that under the design load we do not get the working stresses for which we design.

Mr. Slater. I believe it is quite a common thing among building codes to require that the test load for a floor should be twice the design live load, plus the dead load; here we would be subjecting a floor to more severe loading after it has passed through a fire than it is called upon to meet to demonstrate its strength if no fire test is contemplated.

Mr. Strehan. MR. G. E. STREHAN.—The test standards proposed by the committee relate to full-size tests and classify materials and parts of a building rather than the building as a unit. A building may contain one or all of the several classes of materials, dependent upon the purposes to which it is put. Where the fire hazard is emphasized, it is essential to have the best type of fire-resisting floor construction and other structural units. Where the life hazard is the determining factor, because of character of occupancy, such as the tenant factory buildings in our large cities, the protection of exit facilities must be emphasized. Presumably the committee intends to make these specifications supplemental to the existing Standard Tests for Fireproof Floor and Partition Construction in so far as they are not contradictory, as no mention is made of criteria for satisfactory tests such as permissible deflection.

Mr. Slater criticises the factor of safety required in the load test following the applications of fire and water. There is apparently some confusion in his mind between the customary workmanship load test specified in building codes and the approval load test specified in the fire test requirements. The workmanship load test specifications required by the New York Building Code state that the construction shall be capable of supporting $1\frac{3}{4}$ times the live load for which it is designed. Such a test is applied in specific cases in the completed building to insure quality of workmanship. The test is not carried to failure, but the construction is required to support the test load without showing undue weakness and usually with a prescribed permissible deflection.

Approval tests for new construction and materials, however, are conducted on test installations with which it is reasonable to assume special care has been taken both in the selection of materials and in workmanship. The New York Building Code requires approval load tests of new combinations of materials,

Mr. Strehan. the fireproof value of which is recognized but the design of which is not susceptible to analysis by accepted engineering principles, before such construction is permitted in actual buildings. The test floor is subjected to its ultimate bearing capacity and is approved for a safe working load of one-sixth of the superimposed load which causes failure of the construction, applied at the third points.

The load test specified by the proposed standards requires the construction to support four times the load for which it is designed, after the application of fire. It may be desirable to vary the factor of safety with the type of protection and to specify different loadings for the 1, 2 and 4-hour protection.

The speaker would also suggest that the committee consider the formulation of a test specification to determine (1) incombustibility, (2) thermal conductivity, (3) imperviousness to moisture, (4) resistance to fracture from sudden heating and cooling, and (5) the structural effectiveness of materials used for fireproofing structural members. In a paper on "Heat-Insulating Properties of Materials Used in Fire-Resistive Construction," presented at this meeting by Mr. W. A. Hull,[1] the tests as described were so conducted that none of the materials commonly accepted for fireproofing maintained the temperatures below the critical point for steel. The requirement of the New York Building Code is that any material accepted as fireproofing must be capable of resisting the action of flame and a heat of 1700° F. (approximately 930° C.) for 2 hours without raising the temperature of the material to be protected above 550° F. (approximately 290° C.) by transmission through a thickness of 2 in.

Actual tests have shown that steel, especially if of small section and high carbon content, protected with 1 in. of concrete—common practice in reinforced concrete slab construction—may be considerably annealed with a consequent loss in strength when subjected to fire. It is urgent, therefore, that requirements and methods of conducting tests be fixed for fire-protective coatings.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part II, p. 422 (1917).—ED.

Mr. Slater.

MR. SLATER.—Mr. Strehan states that the test for New York City which requires a factor of safety of 1¾ is merely a workmanship test, that is to be applied to the floor of a building which has been constructed and to which they do not wish to apply a load which will cause the failure of the building. If that is a proper explanation, it seems to me that there ought then to be tests required which will give a factor of safety of four on a floor for which approval is asked of a system. Is there such a test, and if there is not, to be consistent with the fire-test requirements, should there not be such a test?

Mr. Strehan.

MR. STREHAN.—The building code of the City of New York does specify a load test for systems that are not required to be subjected to fire tests, that are constructed of materials which have been accepted as fireproof materials, and such load test requires a factor of safety of six on the superimposed load; that is, the construction is approved for a safe load equal to one-sixth of the superimposed load which causes failure, and inasmuch as the load is applied at the third points, the test provides a factor of safety of eight on the equivalent uniformly distributed load in simple span construction and approximately eight in continuous construction.

Mr. Slater.

MR. SLATER.—I do not wish to occupy the floor all the time, but just in regard to this last matter, I understand that that factor of safety of six is for floors which are not subject to rational design; is that not the case?

Mr. Strehan.

MR. STREHAN.—That is correct; the building code does not permit approval tests of any system that is amenable to analysis and rational design.

Mr. Slater.

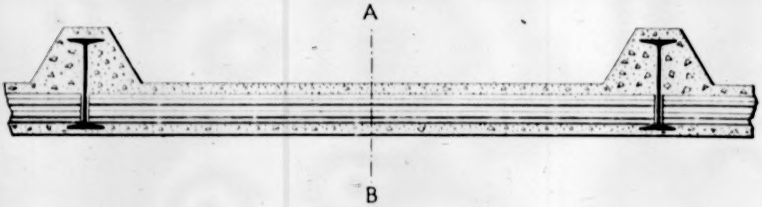
MR. SLATER.—Then it seems to me that, to put them on the same basis, the factor of safety of four should be required on a slab which is subject to analytical design.

Mr. Strehan.

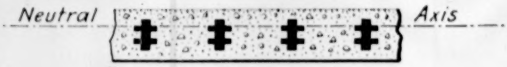
MR. STREHAN.—Any analytical design that is applied to materials which have been approved as fireproof materials naturally results in the usual factor of safety. Neither fire nor load tests are contemplated by the code on systems that are subject to design when constructed of accepted fireproof materials of which the physical constants are known, such as the ultimate compressive strength and the moduli of rupture, etc. Does this answer your question?

Mr. Slater.

MR. SLATER.—I merely mean this, that if we were to arrive at our design from an empirical basis, if we were merely to put reinforcement in beams and slabs and subject the floor panel to a load and after we had found the maximum load which it will carry, apply a factor of safety of four, and say that one-fourth of that is the working load, then probably we might arrive at approximately the same working load as is given by the analytical design. But we do not design slabs in that way; we design them assuming that we get a working stress of 16,000 lb. per sq. in. in the reinforcement, so that we figure on a factor of safety of perhaps $2\frac{1}{2}$; as a matter of fact, we probably get a factor of safety of considerably more than that. However, an engineer having a reputation to guard would not count on a factor of safety as high as four when he is designing with 16,000 lb. per sq. in. as a working stress in mild steel, and I do not believe that specifications should be adopted which compel him to vouch for a load which he cannot justify on any rational basis and which laboratory tests show cannot always be depended upon.



Longitudinal Section.



Transverse Section A-B.

FIG. 1.

Mr. Strehan.

MR. STREHAN.—I think Mr. Slater is under a misapprehension about approval load tests in New York City. You cannot submit to the authorities such a design as that referred to, which is subject to accepted analysis, for a load test. They would not accept such a load test for approval. But a load

Mr. Strehan. test, if I might take a specific case, would be prescribed for a system such as that illustrated in Fig. 1, in which the steel is a structural unit, like that indicated, and is supported both above and below the neutral axis. Present accepted analysis does not apply to such a system. The only alternative is a load test.

Mr. Slater. MR. SLATER.—What factor of safety would be granted on that?

Mr. Strehan. MR. STREHAN.—One-sixth of the breaking load on third-point test, equivalent to approximately one-eighth in continuous construction and exactly one-eighth in simple construction on the basis of a uniformly applied load.

Mr. Slater. MR. SLATER (*by letter*).—In my previous discussion I assumed that the loads intended to be placed upon the specimen during and after the fire test were, the design live load and four times the design live load respectively. This opinion has been confirmed by correspondence with Mr. I. H. Woolson, chairman of the committee.

However, it is specified in the report that the load during the fire test shall be that for which the panel is designed, and that the load after the fire test shall be four times the load carried during the fire test. Since the load carried during the fire test is the sum of the dead and live loads, a strict interpretation of the recommendation would require that the load after the fire test should be four times the sum of the dead load and the live load. I believe it is important that this ambiguity in the working be removed.

In an effort to determine to what extent the results of fire and load tests justify so rigid a requirement as four times the design live and dead load after the fire test, an examination was made of the paper by Mr. Woolson and Mr. Rudolph P. Miller, given in the 1912 Proceedings of The International Association for Testing Materials on "Fireproof Floor Tests." For certain of the tests of reinforced-concrete panels there reported, computations of the strength of both the beams and the slabs were made using the moments and the working stress recommended for design by the "Joint Committee on Concrete and Reinforced Concrete," and the results of these computations are shown in Table I. It will be seen that the test load applied was

Mr. Slater. less than four times the safe live load for all the panels included in the table, except the two panels No. 53 and No. 55, and of these two panels No. 55 was disapproved by the Bureau of Buildings.

It is true that the tests reported show good results and there may be other tests in which as much as four times the design live load was applied, but I have not been able to examine more than the six panels reported in the table. However, when out of six specimens taken at random only two of these had as much as four times the design live load applied, and when of these two panels one was disapproved by the Bureau of Buildings, it would appear that the test record is not sufficient to justify so severe a test requirement as that proposed.

TABLE I.

Reference No.	Safe Live Load, lb. per sq. ft.		Computed Stress, lb. per sq. in.		Ratio Test Load to Safe Live Load.	
	Beam.	Slab.	Beam.	Slab.	Beam.	Slab.
53................	135	160	52 200	48 600	4.45	3.75
55................	152	140	49 000	54 800	3.95	4.29
57................	163	424	49 000	22 000	3.68	1.42
58................	192	648	40 000	14 900	3.13	0.93
59................	272	441	31 000	21 200	2.20	1.36
63................	364	452	24 400	20 700	1.64	1.33

NOTE.—In the computations the moments were taken as 1/8 wl^2 for the beams and 1/12 wl^2 for the slabs, conforming to the recommendations of the Joint Committee.

Working stress in steel taken as 16,000 lb. per sq. in.

One reason assigned by Mr. Strehan in the previous discussion for the necessity of a severe test requirement is that test slabs are always better built than slabs used in actual construction. Such a recognition in specifications is virtually a permission that this practice be followed with no limits placed as to where it should stop. If specifications are based on the assumption that slabs designed for tests are better constructed than slabs built for service, no objection can be raised to such practice and the designer who tries to design correctly is placed at a disadvantage.

MR. W. A. HULL (*by letter*).—There is a notable tendency **Mr. Hull.** running through the report of this committee in the rather consistent recognition and encouragement of the less costly, less massive forms of fire-resistive construction. The term "One-Hour Protection" surely promises to give a comparatively light, inexpensive fire barrier a better standing in the community than any such term as "Temporary Protection" or "Fourth-Class Retardant." In Table I, One-Hour Protection comes first on the list and we find that the maximum water pressure has been reduced from 60 to 50 lb. There is a pronounced, though conservative, movement here toward getting away from the idea of indestructibility, which is in keeping with the new order of things that is coming about, with startling rapidity, in American thought and activity. Just a few years ago, the word "conservation" came into common use with us; now we are coming to use the word "save," though still with occasional apologies. We are coming to realize that there are things we can not afford, in the expenditure of our resources. We already realize that we can not afford to build to burn. It is possible that we are coming to believe that we can not afford to build so heavily, one may almost say wastefully, as to attain indestructibility against the sort of fire that should and can be eliminated from our list of national disgraces.

We are coming, very rapidly, into closer touch with Continental Europe, where the fire departments develop less speed in going to fires than ours do in coming back. There is no cause for haste where conditions preclude the possibility that a fire may assume large proportions. We are informed that for the European fire regulators, one can scarcely say fire fighters, it is not an uncommon practice to let a fire burn itself out, in a restricted portion of a building, rather than damage the rest of the building, with its contents, by drenching it with water.

It seems certain that a new order of things is coming with more speed than that to which we are accustomed, in our whole scheme of building against fire. We have been building a few buildings that are designed to withstand 4-hour fires of 1700° F. average temperature without great damage to the load-bearing structure, apparently on the assumption that such fires are,

Mr. Hull. and must continue to be, inevitable things in American experience. We have been giving much attention to the problems of building to withstand conflagration. Is it not, perhaps, time to divert more of our energy to the task of building to *prevent conflagration?* Surely we shall find it a better business proposition to build many buildings in which no fire can gain much headway than to build a few buildings that are designed to withstand such fires as do gain headway, under present conditions, in the many buildings that have been built to burn.

In the matter of water application, it is now realized that the day of fighting big fires with high-pressure hose streams is passing, and the day of few and small fires, confined by fire stops and controlled by sprinklers and chemicals, is almost in sight. Perhaps we shall find that it is not good business, on the whole, to build against even the 50-lb. hose stream as the chances of encountering such a stream become more and more remote.

In the specifications for floor tests we see recognition for the types of floor that can not well be designed to carry 150 lb. per sq. ft. The standard requirement of increasing the load to four times the design load has not yet been disturbed. Perhaps its turn will come next. There is much to be said in favor of this specification. It represents both precedent and sound judgment. On the other hand, we are again brought face to face with the question of the relative importance of indestructibility as compared with fire control. Obviously, the better the money that is put into a building is distributed, for the purpose of preventing fires from getting under way, the less is the likelihood that any portion of it will ever encounter the long, severe, uncontrolled fire that is represented by our 4-hour fire tests. It follows that as we learn to spend our money wisely enough and consistently enough to reduce the probability of the severe fire, the relative value of the floor that can come through a severe fire without structural injury will become less and the safety of both human and property occupants of buildings will be very greatly improved.

Mr. Ingberg. MR. S. H. INGBERG (*by letter*).—I should like to call attention to what I believe to be an excessive load requirement for floors in the standard test proposed. Requiring the member to stand a load equal to four times the design load (dead plus live load), particularly after a severe fire exposure of up to 4 hours duration, followed by water application, seems very excessive and does not conform to accepted principles of design. **Mr. Ingberg.**

The utimate strength of a floor, other than arch constructions or semi-arch constructions which are limited to relatively short spans, is determined by the yield point strength of the steel, whether it be in the form of structural shapes or reinforcing bars, assuming that the other material composing the floor is of normal quality and properly placed. Other elements will sometimes be present that may add to the strength, such as statical indetermination, as in the case of two-way reinforced concrete slabs, arch action, and tension in the concrete; but these are not considered in design and should not be considered in making specifications for tests. Also, the floors being tested without restraint, and subjected, previous to application of excess load, to prolonged fire and subsequent water application, little or no added strength would be afforded by arch action or tension in the concrete on spans of normal length, and no statical indetermination is present in the case of structural steel beams on simple spans or one-way reinforced concrete or combination tile and concrete floors.

The fact that the yield-point strength of steel determines its ultimate usefulness in a structure, where it is in a tension or compression chord in cross-bending, is due to the large elongation that takes place at the yield point, with little or no increase in load-carrying capacity (sometimes a slight drop in the same), which causes large deflection in the member, resulting in failure or buckling of the compression chord due to the rise of the neutral axis, with consequent reduction of compression area and increase in outer fiber compressive stress. The unit working stress quite generally allowed for steel is 16,000 lb. per sq. in., with some reduction for length of member in the case of compression, which provision no more than takes care of eccentricity in loading and lack of straightness for long members. Since the yield points of steel in ordinary use for building construction, excluding the high-carbon grade, range from 33,000 to 40,000 lb. per sq. in., it will be seen that the factor of safety ranges from 2 to 2½.

Mr. Ingberg. Load tests made on isolated panels in completed structures give no certain indication of the resistance of a discontinuous panel fully loaded since, in the former case, the members of adjacent panels partake in the deflection and help to carry the load. From the study of results of tests made on simple members the conclusion is inevitable that the internal resisting moment set up by the stresses in the materials does equal the external moments of the applied loads, and that failure takes place when given stress values are exceeded.

Fireproof construction in materials of common use is now standardized by practice and is generally independent of any fire test requirement, the manner of construction being governed instead by limitations in stresses and thickness of covering materials, which, particularly for floors, do not vary greatly as between the principal cities of this country. In so far as these limitations are correct, the fire test requirements should correspond with them. It would evidently be unfair to require a new type of construction for which the building code prescribes no standard of design and which therefore must be submitted to fire and load tests, to come up to standards of performance greatly in excess of those prescribed for constructions that, due to established use, are accepted without tests.

REPORT OF COMMITTEE C-6
ON
DRAIN TILE.

Committee C-6 completed and thoroughly revised the Standard Specifications for Drain Tile in 1916. Since their adoption by letter ballot about 8000 reprints have been distributed widely, and the specifications seem to be coming into use by drainage engineers very rapidly.

A well-attended meeting of Committee C-6 was held at Atlantic City at the time of the last Annual Meeting, and another at the same time and place of this year's meeting. No other meeting has been found necessary this year, as it seems inadvisable to make any amendments to the Standard Specifications for Drain Tile until fairly extensive data of experience in their use are available.

The two vacancies which existed in the membership of the committee at the time of the last annual report have been filled by the appointment of Mr. Benjamin Brooks, of Kansas City, and of the Portland Cement Association (C. M. Wood), Chicago, Ill., both representing producing interests. The committee now consists of 16 members, 8 non-producers and 8 producers.

This report has been referred to letter ballot of the committee, which consists of 16 members, of whom 14 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. Marston,
Chairman.

REPORT OF COMMITTEE C-7

ON

LIME.

Committee C-7 recommends that the proposed Tentative Specifications for Masons' Hydrated Lime, which are appended to this report, be printed by the Society as tentative, with a view of superseding the present Standard Specifications for Hydrated Lime (Serial Designation: C 6–15).[1] The committee deems this change desirable because of the existence of certain objectionable features in the present specifications for hydrated lime.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 14 have voted affirmatively, 1 negatively, and 1 has refrained from voting.

Respectfully submitted on behalf of the committee,

James S. Macgregor,
Chairman.

E. L. Conwell,
Secretary.

Editorial Note.

The proposed tentative specifications referred to in this report were accepted for publication among the Tentative Standards of the Society, and appear on pages 661–664.

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[1] 1916 Book of A.S.T.M. Standards, p. 472.

REPORT OF COMMITTEE C-8
ON
REFRACTORIES.

Committee C-8 recommends that the following proposed tentative standards, appended to this report, be published in the Proceedings of the Society:

Proposed Tentative Methods for Ultimate Chemical Analysis of Refractory Materials;

Proposed Tentative Test for Refractory Materials under Load at High Temperatures; and

Proposed Tentative Test for Slagging Action of Refractory Materials.

The committee presents an investigation of the slagging action of refractory brick by Messrs. C. E. Nesbitt and M. L. Bell, which is appended hereto.

The committee requests suggestions and information from members of the Society that will help them in their work.

The returns from the letter ballot on the proposed tentative standards are as follows:

Tentative Standard.	Affirmative.	Negative.	Not Voting.
Proposed Tentative Method for Ultimate Chemical Analysis of Refractory Materials....................................	24	0	3
Proposed Tentative Test for Refractory Materials under Load at High Temperatures....................................	25	0	2
Proposed Tentative Test for Slagging Action of Refractory Materials....................................	25	0	2

This report has been submitted to letter ballot of the committee, which consists of 27 members, of whom 25 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. V. Bleininger,
Chairman.

Editorial Note.

The proposed tentative methods and the two proposed tentative tests referred to in this report were accepted for publication among the Tentative Standards of the Society, and appear on pages 665–678.

APPENDIX.

SLAG TEST FOR REFRACTORY BRICK USED IN THE IRON AND STEEL INDUSTRY.

By C. E. Nesbitt and M. L. Bell.

Early in the study of the physical properties of refractory material in the iron and steel industry, the necessity for a slag test which would give information as to the relative resistance of refractory brick to various slags and fluxes became apparent. To be of use in specifications it was evident that such a test must be rapid, easily performed, and applicable to any kind of brick or slag, and should as far as possible approach conditions similar to those under which the brick is to be used.

As a basis for a test it was decided to place the brick in contact with a certain slag and apply heat until the slag was thoroughly melted. When cold the amount of penetration was observed. In the preliminary work the piling of the slag on the brick was tried, but the results were negative, as the slag ran off the brick as soon as melted, producing no marked penetration. Kaolin rings were tried in hope of confining the slag but these failed to accomplish their purpose. Pockets were next cut in the brick by chipping. This proved to be successful in confining the slag but the chipping was too slow and it was difficult to secure uniform cavities. Drilling by means of a press was next resorted to, and uniform pockets as near as the nature of brick material would permit were drilled. The bricks were then heated to testing temperature and a known quantity of slag was placed in the drilled cavities. After the bricks had become cold they were broken through the slag cavity and examined. Visual examination proved of small value, as results could not be accurately compared; hence it was found necessary to devise some means by which the amount of penetration could be measured. This was accomplished by sawing the brick so that one of the sawed faces accurately bisected the center of the original cavity, and the area of slag penetration thus exposed was then measured by means of a planimeter.

To standardize the method it became necessary to determine whether the fineness of the slag, the time to which the slag was exposed to the brick, and the amount of slag used in the test had any effect upon the amount of penetration.

To determine the effect of fineness of the slag on the amount of penetration, blast-furnace and heating-furnace slags were selected as representative of the iron and steel industry. Each was ground and separated into two sizes, coarse and fine. The coarse material was that which passed a 40-mesh and remained on a 60-mesh sieve, while the fine was represented by that which passed through a 100-mesh sieve. The slag test was then run in the usual manner on standard hearth and bosh blast-furnace brick. The average results were as follows:

		PENETRATION, SQ. IN.
Blast-furnace slag	40 to 60-mesh	1.54
	100-mesh	1.67
Heating-furnace slag	40 to 60-mesh	1.77
	100-mesh	1.72

From the above results it is apparent that the degree of fineness of the slag does not affect the penetration.

To determine whether the time to which the slag was exposed to the brick, and also whether the amount of slag used in the test affected the penetration, a series of slag tests were run, in which the slag was exposed to the brick at testing temperature for 2, 4 and 6 hours, with the quantity of slag varying from 35 to 140 g. The results of slag penetration are given in Table I.

From Table I it is shown that the amount of penetration is not increased by keeping the brick in contact with the slag for a longer period than two hours. Preliminary work had shown that one hour would in most cases give complete penetration, so that the adoption of two hours was considered sufficient to guarantee full action of the slag.

It will also be noted that there are two variables, namely, the amount of slag used and the area exposed to slag action. To make the average results comparable these variables must be eliminated. This was accomplished by reducing the area exposed to slag action to a unit figure by dividing the area of the standard cavity (5.94 sq. in.) into each of the other areas (columns 3, 4 and 5 in Table I). The ratio figures thus obtained were divided into the average slag penetration and the results (slag penetration divided by ratio) made comparable. These figures prove that increasing the amount of slag does not affect the slag penetration, when reduced to a unit of area exposed to slag action. The variation in the results are within checking limits and the difference due to the variation in the bricks themselves.

TABLE I.—PENETRATION OF SLAG FOR VARIOUS TIMES OF EXPOSURE AND AMOUNTS OF SLAG.

Time of Exposure, hours.	Penetration for—Grams of Slag used, sq. in.			
	35	70	105	140
2	0.49	0.58	....	....
2	0.51	....	0.79	....
2	0.45	....	....	0.79
4	0.51	0.58	....	....
4	0.43	....	0.78	....
4	0.43	....	....	0.83
6	0.46	0.52	....	....
6	0.44	....	0.70	....
6	0.52	....	....	0.89
Average	0.45	0.56	0.76	0.84
Area exposed to slag action, sq. in.	5.94	7.97	8.57	9.44
Ratio of exposed area to standard cavity	1.00	1.34	1.44	1.59
Average slag penetration ÷ ratio	0.45	0.42	0.53	0.53

The question of the advisability of performing a slag test in a drilled pocket as compared to immersing the brick in molten slag was next studied. Bricks from the same shipment were tested, one-half of them by the drilled-pocket method in the usual way, while the others were placed on edge in a refractory tray or shallow box, in which slag was placed to a depth of 1½ in. All were heated at a uniform rate to 1350° C. and held for 1 hour. After cooling the bricks were cut at right angles to their length into two or three sections, the cuts being about 1 in. apart. The drilled-pocket samples were cut in the usual way, a second cut being then made at right angles to the first. The areas of slag penetration thus exposed were measured with a planimeter; also, the linear inches of slag contact on the surface of the brick were measured. Heating furnace slag was used in this test. Table II gives the results of these tests.

TABLE II.—RESULTS OF SLAG PENETRATION.

Sample.	Area No.	Immersion Method.			Drilled-Pocket Method.		
		Slag Penetration, sq. in.	Slag Contact of Brick, linear in.	Slag Penetration per linear inch of Contact.	Slag Penetration, sq. in.	Slag Contact of Brick, linear in.	Slag Penetration per linear inch of Contact.
A	1	5.50	7.0	0.78	1.67	3.5	0.48
	2	1.68	7.0	0.24	1.48	3.5	0.42
	3	2.50	7.0	0.36	....	...	....
B	1	4.96	8.5	0.58	1.10	3.5	0.31
	2	4.82	8.5	0.55	1.06	3.5	0.30
C	1	0.91	10.0	0.09	0.88	3.5	0.25
	2	0.57	10.0	0.10	0.71	3.5	0.20

From the results it is evident that greater uniformity of results is obtained by use of the drilled pocket than by immersion. The drilling of pockets to contain the slag is also preferable to the use of large trays to contain the slag, because of economy of space in the furnace.

The drilled-pocket method as at present adopted has several points which recommend it as a standard method. It is very flexible, as cavities, slags, temperature, and the amount of slag can be easily changed to correspond to the service conditions under which the bricks are to be used. It is rapid, easily performed, and results are expressed by a definite numerical quantity.

When clay bricks for blast-furnace or similar uses are to be tested, blast-furnace and heating-furnace slags are used. Silica bricks for open-hearth use are tested with open-hearth and heating-furnace slags.

REPORT OF COMMITTEE C-9

ON

CONCRETE AND CONCRETE AGGREGATES.

The work of the committee has been continued along the lines described in its last report.[1] Investigations have included researches in grading and proportioning aggregates; comparative tests of specimens of different shapes and sizes; methods of making and testing laboratory specimens and field specimens of concrete; and causes of defective sand, especially as regards organic impurities and the remedies for these defects.

The committee has appointed several sub-committees to serve on special conference committees with representatives of other committees of the Society.

Valuable assistance has been rendered through the cooperation of commercial and university laboratories. The work of Sub-Committee II on Laboratory Tests for Concrete and Laws of Mechanical Mixtures, Mr. D. A. Abrams, chairman, has been materially assisted by a series of parallel tests on effect of variation in size and grading of the aggregate on the strength of the concrete, carried out by the University of Wisconsin under the direction of Prof. M. O. Withey, by the University of Illinois under the direction of Prof. Arthur N. Talbot, and by the Structural Materials Research Laboratories at the Lewis Institute under the direction of Mr. Abrams. The latter laboratory has also investigated methods of laboratory tests, and has done considerable experimental work for Sub-Committee V on the Effect of Impurities on the Quality of Fine Aggregates, Mr. F. W. Kelley, chairman. This investigation is being handled by Dr. Oscar E. Harder, who has given his full time to the work. The work on the effect of admixtures of different inert powdered materials is also being continued by the Lewis Institute.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 264 (1916).

In making the researches and for the purpose of formulating conclusions with reference to the effect of natural impurities of aggregates on the strength of concretes, the following tests are under way:

1. Disintegrating effect of impurities contained in aggregates used in mortars and concretes which are exposed to—

   (*a*) Repeated and alternate wetting and drying; and

   (*b*) Repeated and alternate freezing and thawing.

2. Relation of impurities in aggregates to setting temperature of cement.

3. Relation of impurities in aggregates to the normal influence of consistency upon the setting time of cement, mortar, and concrete.

The relative values of various strength tests, such as tension, compression, and transverse, have been studied under Sub-Committee IV, Mr. A. T. Goldbeck, chairman. This sub-committee has submitted a preliminary report based on tests thus far made. The results do not conclusively prove the superiority of any one of the tests over the others.

Methods of tests for voids, weights, density, specific gravity, and consistency are under the consideration of Sub-Committee VI, Mr. Cloyd M. Chapman, chairman. Part of the testing program has been carried out and will probably be ready to report upon next year.

RESULTS ACCOMPLISHED.

Much of the work indicated above is still in progress, and while tentative conclusions of considerable interest can be drawn from the tests thus far, they are not yet ready for presentation. Many of these will be taken up next year, and it is expected at that time also to present tentative recommendations for mixing and placing concrete.

In the present report are presented as appendices:

1. Suggested methods for making and testing field specimens of concrete, submitted by Sub-Committee III, Mr. W. M. Kinney, Chairman (Appendix I);

2. Suggested methods of making colorimetric tests for organic impurities in sand, submitted by Sub-Committee V, Mr. F. W. Kelly, Chairman (Appendix II).

These are presented at the present time with a view to getting further information as to their acceptability. Later they will be presented in final form as proposed standards.

In Appendix III is presented a report of a conference committee appointed to serve with a similar committee of D-4.

This report has been submitted to letter ballot of the committee, which consists of 22 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

SANFORD E. THOMPSON,
Chairman.

LEWIS R. FERGUSON,
Secretary.

APPENDIX I.

SUGGESTED METHODS
FOR
MAKING AND TESTING FIELD SPECIMENS OF CONCRETE.

The following methods are presented not as final recommendations but as an outline of what in the opinion of the committee represents the best practice at the present time. The necessity for greater attention to testing concrete in construction, and for the adoption of a proper method for sampling the concrete to represent the product of the various field operations, is recognized by engineers and contractors, especially in view of the tendency in many quarters to use a wet, sloppy concrete which may give a final strength much lower than that upon which the design is based.

The tests are designed to provide an indication of the quality of the concrete which is placed in the structure and character of workmanship in mixing. By providing damp sand storage for the test specimens, variable weather conditions are purposely disregarded although these sometimes greatly affect the final strength of the concrete. In comparing the results, the temperature and weather conditions must be taken into account.

Size and Shape of Specimen.—The test specimen should be of cylindrical form, with length twice the diameter. A mold whose diameter is not less than 4 times the diameter of the largest size aggregate should be used. The sizes most commonly used are 6 by 12-in. and 8 by 16-in. cylinders.

Molds and Apparatus.—Figs. 1 to 3 show types of molds which should be used in the field. Figs. 1 and 2 show types which are designed for repeated use; while the mold shown in Fig. 3 is destroyed in removing test piece, or else has to be re-soldered. While this latter mold is not adapted to continuous use and therefore is more expensive in actual cost, it is quite convenient to use where but few tests are to be made and particularly advantageous where specimens are to be shipped at early stages as the specimens can be left in the molds for shipment. Various modifications of each of these forms will suggest themselves, the only requirements being that they hold their shape during the molding of the specimen and that the ends remain perpendicular to the side.

When bottomless forms are used, it will be necessary to provide a plane surface on which to mold the specimens. Individual plates of glass $\frac{1}{4}$ to $\frac{3}{8}$ in. thick, or metal plates with plane surfaces about 2 in. larger than the diameter of the mold, may be used, placing one under each test piece. A piece of wax paper should be provided to place under each test specimen to prevent the concrete from adhering to the plate, or the plate may be oiled.

A central place should be selected for molding the specimens, and a sand pile provided so that they may be kept in damp sand as described below, to prevent undue evaporation and obtain uniformity of storage conditions.

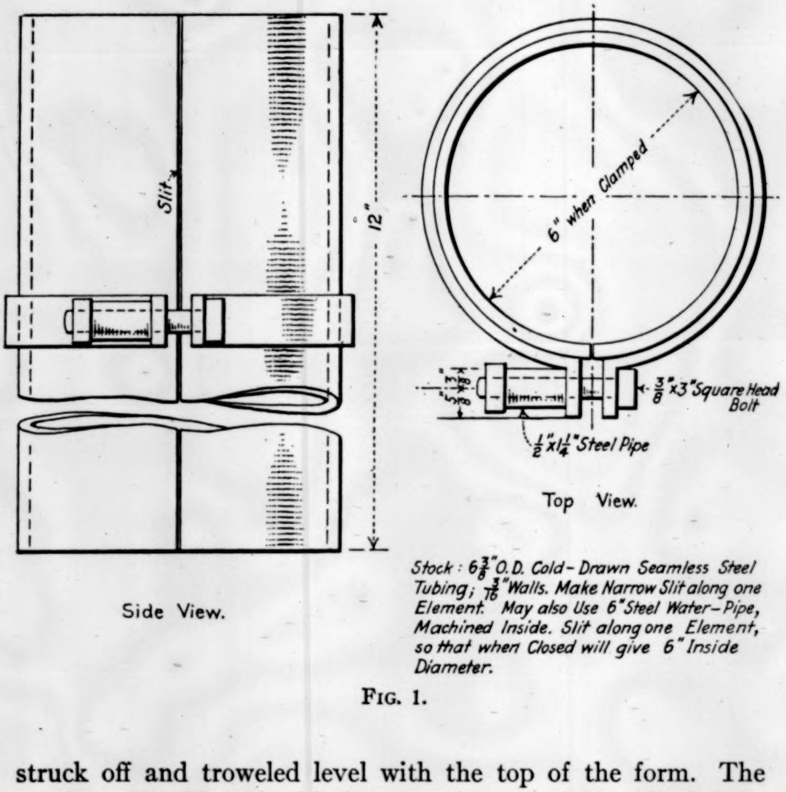
Sampling the Concrete.—Concrete for the test specimens should be taken immediately after it has been placed in the forms. All the material for each sample should be taken from one place. A sufficient number of samples—each large enough to make one test specimen—should be taken at different points so that the specimens made from them will give a fair average of the work. The location from which each sample is taken should be clearly noted for future reference.

In securing samples, the concrete is taken from the mass by a shovel or similar implement and placed in a large pail or in some other receptacle for transporting to the place where the specimens are molded. Care should be taken to see that each specimen represents the total mixture of the concrete at that place.

Molding the Specimen.—The pails containing the samples of concrete should be taken to the place selected for making the test pieces as quickly as possible. To offset segregation of materials during transportation, each sample should then be dumped out of the pail into a non-absorbent water-tight receptacle, and without further mixing immediately placed in the mold. Different samples should not be mixed together, but each sample should make one specimen.

For working the concrete around the sides of the mold, a $\frac{3}{4}$-in. round steel rod, 2 ft. long, should be used.

Ramming should be avoided, but care should be taken to remove air pockets. The freshly made specimen should be



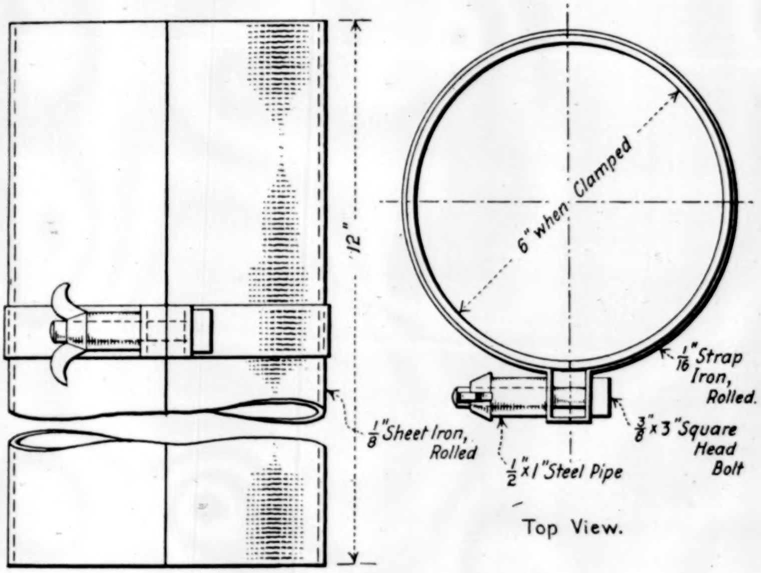
Side View.

Top View.

Stock: 6$\frac{3}{8}$" O.D. Cold-Drawn Seamless Steel Tubing; $\frac{3}{16}$" Walls. Make Narrow Slit along one Element. May also Use 6" Steel Water-Pipe, Machined Inside. Slit along one Element, so that when Closed will give 6" Inside Diameter.

FIG. 1.

struck off and troweled level with the top of the form. The specimen should preferably be capped in the field while it is in the mold so as to be ready for the testing machine. After the concrete has stiffened appreciably and before the molds are removed, neat cement or a rather stiff 1 : 2 mortar may be used to fill the molds level full. A piece of plate glass or machined metal plate should then be worked around on the top of the mortar until it rests on the form. This plate should be oiled or a piece of wax paper be placed between it and the concrete. If the forms are carefully made, this will give top and bottom surfaces perpendicular to the sides of the specimens. To prevent the specimen from drying out, it should be covered or otherwise protected. If desired, the mold itself may be buried in sand while the specimen is being molded.



Side View

Top View.

FIG. 2.

At the end of 48 hours the specimens should be removed from the mold and buried in damp sand. In case the molds shown in Fig. 3 are used, specimens may be buried in damp sand without the removal of the forms, thus permitting shipment of the specimens in the molds. Test specimens made in the mold shown in Fig. 3 may be removed by opening the soldered joint with a sharp tool.

Testing.—Ten days prior to the date of test, specimens should be well packed in damp sand or wet shavings and shipped to the testing laboratory, where they should be stored either in a moist room or in damp sand until the date of the test. It is assumed that ordinarily a 28-day test will be made, although tests at 7 and 14 days will give some indications of the results

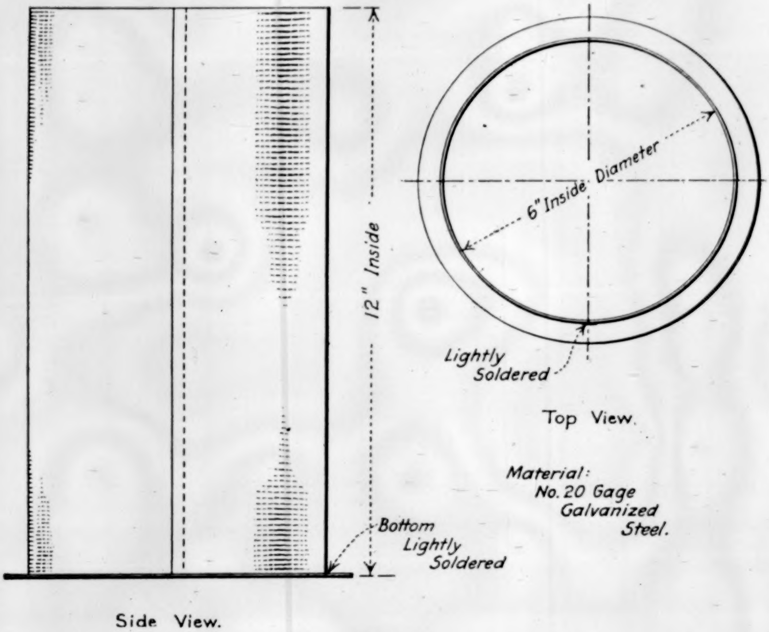

12" Inside
Bottom Lightly Soldered
6" Inside Diameter
Lightly Soldered
Top View.
Material: No. 20 Gage Galvanized Steel.
Side View.

FIG. 3.

to be expected at 28 days. In case 7-day tests are made, the test pieces should remain at the job as long as possible to harden, and should be shipped so as to arrive at the laboratory in time to make the test on the required date.

APPENDIX II.

SUGGESTED COLORIMETRIC TESTS
FOR
ORGANIC IMPURITIES IN SAND.

Researches on the causes of impure sand and the remedies therefor have been carried on during the past year at the Lewis Institute. The most important development has been the formulation of a colorimetric test[1] for organic impurities in sand.

In connection with these studies there have been several series of experiments made on the effect of surface coating.

The colorimetric test may be described briefly as follows:[2]

A sample of sand is digested at ordinary temperature in a solution of sodium hydroxide (NaOH). If the sand contains certain organic materials, thought to be largely of a humus nature, the filtered solution resulting from this treatment will be found to be of a color ranging from light yellow up through the reds to that which appears almost black. The depth of color has been found to furnish a measure of the effect of the impurities on the strength of mortars made from such sands. The depth of color may be measured by comparison with proper color standards.

Two methods of procedure have been developed: (1) For Field Tests; (2) For Laboratory Tests.

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[1] By vote of the committee and by permission of the Executive Committee of the Society, a brief description of this method of test was published in *Circular No. 1*, February, 1917, by the Structural Materials Research Laboratory and under the joint authorship of Duff A. Abrams and Oscar E. Harder. About 3000 copies of the circulars have been placed in the hands of engineers, chemists, contractors, and technical schools. Several testing laboratories are now using the colorimetric test in their examination of sand samples. In some instances it has been incorporated in specifications for sand.

[2] Reprinted from *Circular No. 1* mentioned above.

METHOD FOR FIELD TESTS.

Fill a 12-oz. graduated prescription bottle to the 4½-oz. mark with the sand to be tested. Add a 3-per-cent solution of sodium hydroxide (NaOH) until the volume of the sand and solution, after shaking, amounts to 7 oz. Shake thoroughly and let stand over night. Observe the color of the clear supernatant liquid.

In approximate field tests it is not necessary to make comparison with color standards. If the clear supernatant liquid is colorless, or has a light yellow color, the sand may be considered satisfactory in so far as organic impurities are concerned. On the other hand if a dark-colored solution, ranging from dark reds to black, is obtained, the sand should be rejected or used only after it has been subjected to the usual mortar strength tests.

Field tests made in this way are not expected to give quantitative results, but will be found useful in:

1. Prospecting for sand supplies;
2. Checking the quality of sand received on the job;
3. Preliminary examination of sands in the laboratory.

An approximate volumetric determination of the silt in sand can be made by measuring or estimating the thickness of the layer of fine material which settles on top of the sand. The percentage of silt by volume has been found to vary from 1 to 2 times the percentage by weight.

METHOD FOR LABORATORY TESTS.

To a 200-g. sample of dry sand add 100 cc. of a 3-per-cent solution of sodium hydroxide (NaOH) and digest at ordinary temperature, with occasional stirring, for 24 hours. Filter this solution through a good grade of filter paper; refilter if necessary. The filtrate *must* be clear. Place 10 cc. of the *clear* filtrate in a 50-cc. Nessler cylinder and dilute to 50 cc. with distilled water. Shake thoroughly and let stand until all foam and bubbles disappear. Determine the color value of this cylinder by comparing it with cylinders containing standard solutions of alkaline sodium tannate. Compare the colors by looking through the full depth of the solution with the cylinders held toward a good natural light.

Standard Tannic-Acid Solution for Color Comparison.—The preparation of the standard tannic-acid solution for comparing the color of the filtrate should be begun at the same time as the treatment of the sand. Add 10 cc. of a 2-per-cent solution of tannic acid in 10-per-cent alcohol to 90 cc. of a 3-per-cent solution of sodium hydroxide. The sodium hydroxide combines with the tannic acid to form sodium tannate. Let the solution stand 24 hours at room temperature. Place 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 cc., respectively, of this solution in 50-cc. Nessler cylinders and dilute to the mark with distilled water. The amounts of tannic acid in the different cylinders will then be as shown in the following table:

Alkaline Sodium Tannate in each cylinder—cc.	1	2	3	4	5	6	7	8	9	10
Tannic acid in each cylinder, —mg	2	4	6	8	10	12	14	16	18	20
Color value in parts of tannic acid per million of sand by weight	100	200	300	400	500	600	700	800	900	1000

It is desirable to have good sunlight for comparing the colors; if sunlight is not available, the amount of tannic acid in each of the cylinders containing the standard solutions may be decreased by one-half and the other values in the table modified accordingly.

In case the solution obtained by digesting the sand with the sodium hydroxide is very dark, use less than 10 cc. for the comparison and make the necessary modifications in the calculation of the color values. With very light-colored solutions use more than 10 cc. of the filtrate for the comparisons. The depth of color of the solution decreases on standing, and for that reason the solution should be made up fresh for each day's work.

Method of Calculation.—An example will make clear the method of calculating the color value of a sand. Suppose that 10 cc. of clear filtrate obtained by digesting the sand with 100 cc. of a 3-per-cent solution of sodium hydroxide when diluted to

50 cc. corrresponds in color to the Nessler cylinder containing 12 mg. of tannic acid, or 6 cc. of the alkaline tannate solution. The sand will then have a color value of 600. The 10 cc. of the filtrate placed in the Nessler cylinder is 1/10 of the 100 cc. of 3-per-cent sodium hydroxide solution which was added to the sand, and the sample of sand (200 g.) is 1/5 of a kilogram; therefore, the milligrams of tannic acid per kilogram of the sand, by weight, are 12 x 10 x 5 = 600; or the tannic acid equivalent when expressed in parts per million of the sand, by weight, is 600.

Basis of Colorimetric Test.—The colorimetric test has been applied to sands from about 40 widely distributed deposits in 20 different states. The research to date has brought out the following:

1. Examinations of deposits of defective sands show that surface loam is the principal source of contamination.

2. All natural sands which have been found to be defective on account of the presence of organic impurities have responded to the colorimetric test with sodium hydroxide, and all sands which have given high color values have shown low values in mortar tests.

3. Sands which were similarly graded by screening out and recombining the different sizes to a definite sieve analysis, showed a fairly definite relation between the compressive strengths of 1 : 3 mortars at 7 and 28 days and the color values of the sands.

4. The mortar-making quality of sands known to contain organic impurities has been much improved by removing the organic matter, either by repeatedly digesting them with sodium hydroxide and then washing free from alkali, or by driving off the organic impurities by ignition.

5. When the sodium-hydroxide extracts from sands which mortar tests had shown to be defective were purified and applied as coatings on high-grade sand, that sand was made "defective" or gave much reduced mortar strength.

6. It is impracticable to give exact values for the relation between the color value of a sand and the strength of mortars made from the same sand. However, the tests made thus far show this relation to be about as follows:

COLOR VALUES OF SAND.	REDUCTION IN COMPRESSIVE STRENGTH OF 1 : 3 MORTAR, PER CENT.
250	10–20
500	15–30
1000	20–40
2000	25–50
3000	30–60

The reduction in strength is based on compression tests at ages of 7 days, 28 days, and 3 months, of 1 : 3 mortars made from the same sand, before and after coating with different percentages of organic impurities which had been extracted from defective sands and purified. Tests on mortars made from defective sands as received and after removal of the organic impurities, either by repeated extractions with sodium hydroxide or by ignition, showed that in some cases the reduction in strength for a given color value was even greater than the higher values given above. Frequently the test pieces completely disintegrated in the storage water. The higher reductions in strength for a given color value for a natural sand as compared with the same color value for an artificially coated sand is probably due to the artificial coating being more easily removed by the sodium hydroxide.

Sufficient data are not available to indicate whether or not the effect of a given quantity of organic impurities varies with the grading of the sand. The reduction in strength seems to decrease slightly with the age of the test pieces.

APPARATUS.

The apparatus required for making the colorimetric test of sands will vary according to the nature of the investigation. Two lists are given below: (1) Apparatus for field tests; (2) apparatus for laboratory tests. Sufficient apparatus has been included in each list for tests on 5 samples at a time.

FOR FIELD TESTS.	APPROXIMATE COST.
5 12-oz. graduated prescription bottles	$0.25
Stock of 3-per-cent solution of sodium hydroxide (dissolve 1 oz. of sodium hydroxide in enough water to make 32 oz.)	0.50
	$0.75

FOR LABORATORY TESTS.	APPROXIMATE COST.
15 Nessler cylinders	$7.50
5 3-in. glass funnels	1.00
10 250-cc. beakers	2.00
1 test tube support	0.50
100 qualitative filter papers, 11 cm. diam. (good grade)	0.50
1 100-cc. graduated cylinder	0.75
2 oz. 2-per-cent solution of tannic acid in 10-per-cent alcohol	0.50
1 lb. sodium hydroxide (NaOH) (sufficient for 150 tests)	0.50
1 32-oz. bottle containing 3-per-cent solution sodium hydroxide	0.25
1 10-cc. Mohr's pipette, graduated in $\frac{1}{10}$ cc	0.50
	$14.00

CONCLUDING REMARKS.

Impurities in sands other than organic, such as clay or similar admixtures, if present in considerable quantities, may be expected to affect the strength of the concrete. However, the examination of a large number of defective sands has shown that it is the organic impurities of a humus nature which are responsible for the abnormally low strength of such sands. The presence of these impurities can be detected by the methods described above.

It has been found that the colorimetric test can be made with a greater degree of uniformity by different operators than can the strength tests of mortars from the same sands.

The fact that the colors produced by digesting certain natural sands with sodium hydroxide are similar to those produced by treating tannic acid in the same manner must not be interpreted to mean that the organic matter in sands is necessarily tannic acid, or even a tannate. The chemical compounds which make up the organic material are probably numerous and complicated.

The time actually required for a single determination by the laboratory method is about ½ hour. If tests on as many as 5 samples can be made at once, the total time consumed need not exceed 1 hour. The time required from the beginning to the end of the test is about 24 hours.

Inexperienced operators without technical training or previous experience in work of this character have secured satisfactory results at their first trials.

The colorimetric test does not supersede the ordinary strength test of sand mortar. The latter is still the criterion of the effect of impurities in sand.

APPENDIX III.

REPORT OF JOINT CONFERENCE COMMITTEE OF COMMITTEES C-9 AND D-4

ON

PROVISIONAL DEFINITIONS, TESTS AND METHODS PERTAINING TO NON-BITUMINOUS ROAD MATERIALS.

The Joint Conference Committee of Committees C-9 and D-4, appointed to consider provisional definitions, tests and methods pertaining to non-bituminous road materials recommended by Committee D-4, reports that the following definitions have been unamimously adopted:[1]

Aggregate.—The inert material, such as sand, gravel, shell, slag, or broken stone, or combinations thereof, with which the cementing material is mixed to form a mortar or concrete.

Screen.—In laboratory work an apparatus, in which the apertures are circular, for separating sizes of material.

Sieve.—In laboratory work an apparatus, in which the apertures are square, for separating sizes of material.

Bank Gravel.—Gravel found in natural deposits, usually more or less intermixed with fine material, such as sand or clay, or combinations thereof; gravelly clay, gravelly sand, clayey gravel and sandy gravel, indicate the varying proportions of the materials in the mixture.

The Conference Committee recommends that no definitions be adopted for gravel, sand, and clay.

The Conference Committee has under consideration methods proposed by Committee D-4 for the determination of the specific gravity of sand and other fine highway material, and voids in mineral aggregates; also, definitions for filler, grit, loam, screenings, and silt. It also has under consideration the standardization of methods for sampling gravel, sand, and similar materials.

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[1] Committee D-4 on Road Materials has recommended that these four definitions be published as tentative for one year. See pp. 471–472.—Ed.

REPORT OF COMMITTEE C-10

ON

HOLLOW BUILDING TILE.

Committee C-10 has made no previous report to the Society, and the following statement of organization, scope of work and progress is made:

Committee C-10 on Hollow Building Tile was organized by authority of the Executive Committee of the American Society for Testing Materials during 1915. With Edward Orton, Jr., as temporary chairman, the members appointed eight producers and eight non-producers, met in Cleveland, Ohio, on September 14, 1915, and perfected a permanent organization.

Two meetings of the committee have been held. Since the Regulations Governing Standing Committees requires the election of officers in the even years, a letter ballot was taken during March, 1916, and the officers as elected at the first meeting of the committee were unanimously re-elected for two years.

Mr. V. G. Marani, who was chosen as chairman of Sub-Committee IV, found that he would not have time to devote to this work and therefore resigned. His successor as chairman of the sub-committee has not been chosen, but Professor A. P. Mills, of Cornell University, has been appointed to fill the vacancy on the general committee.

Mr. W. G. Demorest has severed his connections as a member of the committee. His successor has not yet been appointed.

At the first meeting, the general field of investigation was discussed at some length and the work divided among four sub-committees, each being assigned to a particular field for investigation.

Sub-Committee I on Strength and Load Tests (*J. H. Griffith, Chairman*).—The work of this sub-committee includes the investigation of the behavior of individual tile with flues or cells horizontal and vertical and of walls under various conditions of loading.

Sub-Committee II on Fire Tests (E. V. Johnson, Chairman).—The work of this sub-committee includes the investigation of hollow building tile as a fire retardant, and the effect of fire and water on tile under various conditions.

Sub-Committee III on Absorption and Frost Resistance (Edward Orton, Jr., Chairman).—The work of this sub-committee includes the investigation of hollow building tile as a suitable material for underground building work and the effect of absorption and frost upon the strength and durability.

Sub-Committee IV on Insulation and Acoustics (chairman not appointed).—The work of this sub-committee includes the investigation of hollow building tile to determine if possible the value of this material for insulation and acoustics.

Many tests have been made on hollow building tile from time to time, so the first consideration demanding the attention of the committee was therefore the collection, review and tabulation of all existing data, in order that the committee could know what has been done and would not duplicate any reliable tests already made. The committee has had fair response from laboratories, manufacturers and others who had anything to offer. The collecting of data is still in progress.

The second meeting of the committee was held in Cleveland on February 22, 1916, to discuss the outline of tests suggested by Sub-Committee I on Strength and Load Tests. The question of number of specimens, the size of tile, capping, adjustable block, speed of testing machine, and recording of data were all discussed. The tests to be made for absorption, as a part of Sub-Committee III work to be carried on in conjunction with Sub-Committee I, were settled. These recommendations were then printed and sent out to cooperating laboratories for their information and guidance in the conducting of physical tests on individual tile and tile walls.

Sub-Committee I is the only one which has been able to get started on actual testing. The work is progressing satisfactorily and much information is being collected.

It would be unwise at this time to draw any conclusions and this report, therefore, is simply one of progress and gives in a general way the scope of the work and the investigations under way. Appendix I relates to Compression Tests, Appendix II to Absorption Tests and Appendix III to Wall Tests.

The committee wishes to express its appreciation to the manufacturers of tile who have so generously donated their product and for the cooperation of the various laboratories, which have been carrying on the tests laid out by Sub-Committee I, and for the offer of other laboratories of their facilities to carry on the work. The following laboratories are now testing or have completed the work assigned them. Owing to there having been practically no funds at the committee's disposal, the laboratories have donated all of their services. Others have signified their intention of assisting, but up to the present time have not been furnished tile for testing.

INSTITUTION.	DIRECTOR.
Bureau of Standards	S. W. Stratton
University of California	C. Derleth
Case School of Applied Science	R. H. Danforth
Cornell University	A. P. Mills
University of Illinois	A. N. Talbot
University of Michigan	F. N. Menefee H. L. Abbott
Ohio State University	C. T. Morris
Oregon Agricultural College	S. H. Graf
University of Pittsburgh	J. Hammond Smith
University of Toronto	Peter Gillespie
University of Washington	A. H. Fuller
University of Wisconsin	M. O. Withey

This report has been submitted to letter ballot of the committee, which consists of 15 members, of whom 10 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

L. H. PROVINE,
Chairman.

APPENDIX I.

COMPRESSION TESTS OF TILE.

In order to have certain principles of procedure and to determine particular information desired by Committee C-10, the following instructions were sent out to cooperating laboratories. The question of departure from these instructions through any exigency was left to the judgment of the directors of the laboratories.

SELECTION OF SPECIMENS OF INDIVIDUAL TILE FOR TESTING.

Number of Specimens; Sampling at Kiln.—The number of tile accepted from any one manufacturer will be 60. Of these, 45 will be for tests, the balance providing for contingencies of breakage, defective tests or special experimentation, etc. Tiles commonly used for walls and partitions and of three thicknesses will be chosen, namely, 4 in., 8 in. and 12 in., as giving a fair average of the manufacturer's product. The groups of 60 shall be sampled at the kiln and marked by the manufacturer as given in the schedule of Table I. In case of manufacturers making types of construction which do not fall in this schedule, a special program conforming as near as possible to the schedule will be arranged on request.

TABLE I.—SCHEDULE OF SAMPLING AND MARKING.

Dimensions of Tile, in.	Number of Tile.	Position of Tile when Sampled at the Kiln.	Mark on Tile.	Degree of Burning.
4 by 12 by 12; 3 cells......	4	From bottom course..........	L	Low
	12	From mid height course......	M	Medium
	4	From top course.............	H	Hard
	20			
8 by 12 by 12; 2 or 4 cells...	20	Similarly selected and marked to correspond with above.		
12 by 12 by 12; 4 or 6 cells...	20	Similarly selected and marked to correspond with above.		
Grand total..............	60	tiles sampled and marked as noted above.		

When a laboratory is limited in the capacity of its testing machine the unit may consist of specimens 4 in., 6 in. and 8 in. thick, otherwise sampled and marked to correspond with the above.

It is the intent to let the medium-burned tile control the average of the kiln while the others fix the extremes of variations in product. It is desired, as far as possible, that the representative of the laboratory shall be present at the sampling. Otherwise the manufacturer is urged to appoint a competent man of his force for supervising the selection of specimens according to the schedule as arranged.

INSTRUCTIONS FOR PHYSICAL TESTS.

Plaster Paris Capping.—The tile, if exposed to moisture, should be permitted to dry out. The surfaces which are to be capped with plaster (see compression tests) shall be first shellaced. These surfaces shall then be capped with a suitable coat of plaster of Paris, a true surface being secured by pressing out the excess on a smooth plate of steel or glass. The resulting coat should be of uniform thickness not exceeding $\frac{1}{8}$ in.

TABLE II.—SCHEDULE OF TEST PIECES.

Dimensions of Tiles, in.	Number of Tiles Tested (A).	Number of Tile of (A) having Stress-Strain and Absorption Readings.	Mark on Tile Denoting Degree of Burning.	Position of Tile in Testing Machine.
4 by 12 by 12; 3 cells......	1	1	L	On end
	3	1	M	
	1	1	H	
	1	..	L	On edge
	3	..	M	
	1	..	H	
	1	..	L	Flat
	3	..	M	
	1	..	H	
Total........................	15 specimens 4 by 12 by 12 in. tile; stress-strain measurements and absorption on the three specimens indicated.			
8 by 12 by 12; 2 or 4 cells...	15 specimens 8 by 12 by 12 in. tiles; tested as above.			
12 by 12 by 12; 4 or 6 cells...	15 specimens 12 by 12 by 12 in. tiles; tested as above.			
Grand total..............	45 specimens, 9 with stress-strain readings.			

Compression Tests.—Tests are to be made within a period of 5 to 24 hours after placing of plaster caps. Forty-five tiles out of the group of 60 are to be tested in ordinary compression, and 9 of these 45 shall have additional stress-strain measurements taken according to the schedule of test pieces given in Table II. The type of tile should be those commonly used for walls and partitions, with 2, 3, 4 or 6 cells (flues) as the case may be.

DETAILS OF COMPRESSION TESTS.

Oscillating Adjustable Block.—Any standard type is acceptable. This, where practicable, should be placed on the top of specimen (or it should be otherwise noted in data). Care should be taken to insure a uniform initial bearing of testing machine platens on the upper and lower faces of test specimens.

Speed of Testing Machine.—The speed of the moving head shall be not less than 0.01 in. per minute nor more than 0.05 in. per minute. It is requested the actual speed used in testing be stated in the logs in order to furnish information for Committee C-10 to be used in devising standard methods of testing.

Test Data.—Record the actual dimensions of tile, the net and gross areas for the different positions in testing machine, the marks "L," "M" and "H," identifying the degree of burning, color as light, medium, or dark, the name of manufacturer and the type of clay and its general characteristics. Determine loads at incipient fractures or cracking and maximum loads in pounds and pounds per square inch. Record moduli of elasticity of the nine tiles (and if practicable the elastic limit). An initial load of 100 lb. per sq. in. should be taken for the zero of stress-strain readings. These shall be continued at 500 lb. per sq. in. increments of load (closer values for elastic limit) up to a point as near failure of tile as is practicable for the observer. The absorption factors are to be given for these nine tiles as hereinafter provided for.

NOTE.—The type of extensometer is left to the discretion of laboratory. The method pursued by the U. S. Bureau of Standards in taking stress-strain readings is to take four sets of readings at about equal intervals around the tile with an 8-in. Berry strain gage. Small brass or German silver plugs of $\frac{3}{16}$-in. diameter by $\frac{3}{8}$ in. long with appropriate holes for setting gage are set with plaster of Paris in holes drilled in the tile. A $\frac{1}{2}$-in. granite cutter's pneumatic tool is used in drilling the holes. This requires compressed air at 80-lb. pressure. The tool is supplied by Thos. Dallet Co., Philadelphia, Pa., and other manufacturers. Any standard method is acceptable for taking stress-strain readings.

Following are results of compression tests made by the various laboratories.

TABLE III.—COMPRESSION TESTS ON RECTANGULAR-SHAPED TILE MADE BY THE BUREAU OF STANDARDS (PITTSBURGH LABORATORY).

TILE FROM OHIO.

Size of Specimen, in.	How Tested.	Color.[1]	Net Section Area, sq. in.	Maximum Load.		Modulus of Elasticity, lb. per sq. in.
				lb.	lb. per sq. in.	
4 by 5 by 12......	End	Light	10.11	75 825	7500	4 170 000
	"	Dark	9.98	74 850	7500	4 370 000
	"	"	9.77	68 390	7000	4 410 000
					Aver....7330	4 317 000
	Edge	Medium	15.37	69 000	4490	
	"	"	15.37	76 700	4990	
	"	"	15.25	91 500	6000	
					Aver....5160	
	Flat	Medium	14.16	102 350	7230	
	"	"	14.00	104 800	7490	
	"	"	14.04	125 640	8950	
					Aver....7890	
5 by 8 by 12......	End	Medium	16.79	123 420	7350	4 020 000
	"	"	16.79	100 740	6000	3 580 000
	"	"	16.79	104 380	6220	3 300 000
					Aver....6520	3 633 000
	Edge	Medium	13.55	65 400	4826	
	"	Dark	14.52	85 850	5910	
	"	Medium	13.55	79 800	5890	
					Aver....5540	
	Flat	Medium	23.08	135 000	5850	
	"	"	22.25	128 500	5780	
	"	Dark	23.30	143 350	6150	
					Aver....5930	
3 by 12 by 12.....	End	Light	16.02	80 580	5030	4 090 000
	"	Dark	16.24	74 000	4560	2 830 000
	"	Light	14.99	74 950	5000	4 000 000
					Aver....4860	3 640 000
	Edge	Medium	10.32	65 500	6350	
	"	"	10.32	64 050	6210	
	"	"	11.16	41 500	3720	
					Aver....5430	
	Flat	Medium	21.53	137 400	6380	
	"	"	21.99	152 100	6920	
	"	"	21.09	128 300	6080	
					Aver....6460	

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[1] The "burn" is to be judged from the color. This work was started before Committee C-10 was organized The sampling according to the program was not carried out.

TABLE III.—BUREAU OF STANDARDS TESTS (*Continued*).

Size of Specimen, in.	How Tested.	Color.[1]	Net Section Area, sq. in.	Maximum Load.		Modulus of Elasticity, lb. per sq. in.
				lb.	lb. per sq. in.	
3 by 12 by 12.....	End	Red	17.43	95 370	5480	4 180 000
	"	Yellow	17.23	77 535	4500	3 760 000
	"	Dark	16.89	89 680	5310	3 570 000
					Aver.... 5100	3 837 000
	Edge	Light	10.71	58 000	5420	
	"	Medium	11.13	49 450	4440	
	"	Dark	10.85	37 800	3480	
					Aver.... 4450	
	Flat	Light	21.60	141 550	6550	
	"	Medium	21.72	154 300	7100	
	"	Dark	21.03	210 000	9990	
					Aver.... 7550	
4 by 12 by 12.....	End	Red	19.44	106 920	5500	3 780 000
	"	Dark	18.79	135 260	7200	4 840 000
	"	Red	20.70	154 700	7470	4 360 000
					Aver.... 6720	
	Edge	Light	12.47	47 000	3770	
	"	Medium	12.24	67 530	5520	
	"	Dark	12.47	61 650	4940	
					Aver.... 4740	
	Flat	Medium	21.84	170 130	7790	
	"	Dark	23.06	112 030	4860	
	"	Light	23.26	146 020	6280	
					Aver.... 6310	
4 by 12 by 12.....	End	Medium	20.63	134 095	6500	4 640 000
	"	"	20.58	133 770	6500	4 970 000
	"	Dark	20.27	132 000	6510	4 750 000
					Aver.... 6500	4 787 000
	Edge	Light	13.26	49 000	3700	
	"	Medium	12.55	105 880	8440	
	"	Dark	12.72	85 650	6730	
					Aver.... 6290	
	Flat	Medium	25.74	185 070	7190	
	"	"	25.58	202 000	7900	
	"	Dark	25.80	192 120	7450	
					Aver.... 7510	

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[1] The "burn" is to be judged from the color.

TABLE III.—BUREAU OF STANDARDS TESTS (*Continued*).

Size of Specimen, in.	How Tested.	Color.[1]	Net Section Area, sq. in.	Maximum Load.		Modulus of Elasticity, lb. per sq. in.
				lb.	lb. per sq. in.	
6 by 12 by 12.....	End	Red	22.80	181 080	7940	3 760 000
	"	Dark	24.90	170 000	6830	4 720 000
	"	Medium	25.56	166 140	6500	3 910 000
					Aver.... 7090	4 130 000
	Edge	Medium	13.56	66 770	4920	3 180 000
	"	"	12.12	66 680	5500	3 510 000
	"	"	13.06	55 040	4210	3 430 000
					Aver.... 4880	3 373 000
	Flat	Medium	23.86	181 340	7600	
	"	"	23.96	218 650	9130	
	"	"	24.62	185 300	7530	
					Aver.... 8090	
6 by 12 by 12.....	End	Dark	29.63	305 180	10 300	5 960 000
	"	"	31.32	291 340	9 300	4 700 000
	"	"	30.03	321 860	10 700	5 370 000
					Aver.. 10 100	5 343 000
	Edge	Light	19.34	115 530	5970	3 970 000
	"	Dark	18.75	120 300	6420	5 540 000
	"	"	19.06	130 860	6860	5 330 000
					Aver.... 6420	4 947 000
	Flat	Medium	25.38	201 920	7950	
	"	Dark	26.11	170 080	6510	
	"	"	25.85	158 660	6130	
					Aver.... 6860	
6 by 12 by 12.....	End	Medium	33.78	310 300	9 190	6 260 000
	"	"	33.46	413 540	12 360	5 430 000
	"	Dark	33.55	319 100	9 510	5 380 000
					Aver.. 10 350	5 690 000
	Edge	Dark	22.13	142 900	6460	4 700 000
	"	Medium	22.32	145 850	6540	4 550 000
	"	Dark	21.69	128 700	5930	5 700 000
					Aver.... 6310	4 983 000
	Flat	Medium	29.87	180 320	6040	
	"	Dark	29.09	151 180	5200	
	"	"	30.45	147 500	4840	
					Aver.... 5360	

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[1] The "burn" is to be judged from the color.

TABLE III.—BUREAU OF STANDARDS TESTS (*Continued*).

Size of Specimen, in.	How Tested.	Color.[1]	Net Section Area, sq. in.	Maximum Load.		Modulus of Elasticity, lb. per sq. in.
				lb.	lb. per sq. in.	
8 by 12 by 12.....	End	Dark	26.92	241 400	8970	4 540 000
	"	Medium	27.46	211 920	7720	4 070 000
	"	"	27.61	208 200	7540	4 700 000
					Aver....8080	4 437 000
	Edge	Medium	12.19	56 180	4610	3 240 000
	"	Dark	11.26	64 300	5710	4 810 000
	"	Medium	12.00	48 410	4030	2 930 000
					Aver....4780	3 660 000
	Flat	Medium	23.66	201 340	8510	
	"	Dark	22.93	192 200	8382	
	"	"	23.34	217 500	9320	
					Aver....8740	
8 by 12 by 12.....	End	Dark	37.49	272 920	7280	4 540 000
	"	Medium	39.54	251 340	6360	4 070 000
	"	Light	44.52	240 240	5400	2 140 000
					Aver....6350	3 583 000
	Edge	Dark	20.73	112 540	5430	6 160 000
	"	Medium	20.27	85 250	4210	4 070 000
	"	Light	19.74	99 360	5030	2 460 000
					Aver....4890	4 230 000
	Flat	Dark	27.76	177 000	6378	
	"	Medium	27.56	173 800	6310	
	"	"	28.41	147 640	5200	
					Aver....5960	
8 by 12 by 12.....	End	Light	40.22	211 390	5260	2 660 000
	"	Medium	42.08	270 860	5440	3 190 000
	"	Dark	41.82	201 700	4820	1 880 000
					Aver....5510	2 573 000
	Edge	Light	20.99	123 380	5880	3 240 000
	"	"	21.59	86 360	4000	1 910 000
	"	"	21.16	108 790	5140	2 660 000
					Aver....5010	2 603 000
	Flat	Medium	31.03	143 850	4635	
	"	"	30.20	124 940	4137	
	"	Light	30.39	157 520	5183	
					Aver....4650	

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[1] The "burn" is to be judged from the color.

TABLE III.—BUREAU OF STANDARDS TESTS (*Continued*).

Size of Specimen, in.	How Tested.	Color.[1]	Net Section Area, sq. in.	Maximum Load.		Modulus of Elasticity, lb. per sq. in.
				lb.	lb. per sq. in.	
10 by 12 by 12.....	End	Light	39.00	193 600	4960	2 190 000
	"	Dark	37.36	281 630	7540	4 130 000
	"	Medium	37.82	287 800	7610	3 970 000
					Aver....6700	3 430 000
	Edge	Medium	20.76	108 100	5210	4 020 000
	"	"	20.47	98 340	4800	3 240 000
	"	Dark	20.57	129 780	6310	3 480 000
					Aver....5440	3 580 000
	Flat	Medium	21.55	92 310	4280	3 450 000
	"	"	21.53	88 860	4130	2 720 000
	"	"	21.20	74 450	3510	2 720 000
					Aver....3970	2 963 000
10 by 12 by 12.....	End	Medium	41.98	279 140	6650	4 810 000
	"	"	43.00	379 500	8830	3 660 000
	"	Dark	53.76	389 840	9120	6 160 000
					Aver....8200	4 877 000
	Edge	Dark	20.69	178 820	8640	5 430 000
	"	"	20.57	159 480	7750	4 180 000
	"	Medium	20.79	148 700	7150	3 710 000
					Aver....7850	4 440 000
	Flat	Light	28.48	131 450	4620	2 140 000
	"	Dark	25.69	186 400	7260	4 700 000
	"	"	26.00	141 200	5430	5 750 000
					Aver....5770	4 237 000
10 by 12 by 12.....	End	Medium	46.38	407 860	8792	4 230 000
	"	"	48.60	407 440	8382	3 930 000
	"	"	48.17	419 040	8706	3 550 000
					Aver....8630	3 903 000
	Edge	Medium	22.87	128 440	5614	3 400 000
	"	Dark	22.81	127 920	5607	3 866 000
	"	Medium	23.58	127 240	5394	2 720 000
					Aver....5540	3 327 000
	Flat	Medium	30.96	133 900	4330	3 760 000
	"	"	30.19	144 420	4780	4 490 000
	"	Dark	30.23	131 060	4340	6 060 000
					Aver....4480	4 770 000

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[1] The "burn" is to be judged from the color.

TABLE III.—BUREAU OF STANDARDS TESTS (*Continued*).

Size of Specimen, in.	How Tested.	Color.[1]	Net Section Area, sq. in.	Maximum Load.		Modulus of Elasticity, lb. per sq. in.
				lb.	lb. per sq. in.	
12 by 12 by 12.....	End	Dark	45.10	277 520	6153	4 030 000
	"	Medium	47.38	348 000	7350	4 070 000
	"	"	42.52	303 200	7130	5 540 000
					Aver....6880	4 547 000
	Edge	Medium	22.26	115 800	5202	3 970 000
	"	"	22.68	122 580	5402	4 180 000
	"	"	22.59	105 020	4649	2 980 000
					Aver....5080	3 710 000
12 by 12 by 12.....	End	Medium	47.91	334 440	6980	4 180 000
	"	"	47.25	318 450	6740	3 970 000
	"	"	45.78	329 960	7206	4 650 000
					Aver....6980	4 267 000
	Edge	Medium	21.69	106 950	4932	3 820 000
	"	"	22.09	96 660	4376	2 820 000
	"	"	22.03	100 000	4540	2 690 000
					Aver....4620	3 110 000
	Flat	Medium	28.44	126 300	4442	2 590 000
	"	"	27.96	99 690	3565	2 140 000
	"	"	27.64	133 980	4848	3 710 000
					Aver....4290	2 813 000
12 by 12 by 12.....	End	Light	55.69	353 220	6342	2 870 000
	"	"	55.30	312 500	5650	3 240 000
	"	"	55.64	296 200	5324	3 500 000
					Aver....5770	3 203 000
	Edge	Light	30.91	119 620	3870	2 090 000
	"	"	30.27	135 700	4483	2 770 000
	"	Medium	28.18	146 190	5188	3 970 000
					Aver....4510	2 943 000
	Flat	Medium	28.30	126 550	4472	3 600 000
	"	Light	29.97	104 315	3481	2 090 000
	"	Medium	29.37	146 500	4988	3 240 000
					Aver....4310	2 977 000

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[1] The "burn" is to be judged from the color.

TABLE IV.—COMPRESSION TESTS
MADE BY
CASE SCHOOL OF APPLIED SCIENCE.
TILE FROM PENNSYLVANIA.

Size of Specimen, in.	How Tested.	Degree of Burning.	Net Section Area, sq. in.	Load at First Crack.		Maximum Load.	
				lb.	lb. per sq. in.	lb.	lb. per sq. in.
4 by 12 by 12...	End	Medium	16.29	63 600	3905	114 700	7040
	"	"	16.70	54 700	3280	112 400	6740
	Edge	Low	11.12	10 230	920	38 740	3470
	"	Medium	11.24	6 000	533	33 730	3000
	"	"	10.79	2 300	213.5	20 500	1900
	"	"	10.45	2 500	239.5	22 000	2100
	"	Hard	10.02	4 000	399	29 300	2920
	Flat	Low	20.12	31 000	1540	86 000	4280
	"	Medium	20.75	5 200	251	83 900	4040
	"	"	16.52	3 600	218	55 050	3330
	"	"	18.90	8 700	460	59 500	3150
	"	Hard	21.30	7 700	361	47 850	2245
8 by 12 by 12...	End	Medium	36.76	no crack		+200 000	+5500
	"	"	40.76	169 230	4160	201 800	4950
	Edge	Low	17.78	35 000	1970	68 700	3880
	"	Medium	23.30	15 000	645	99 000	4250
	"	"	17.52	16 000	913	127 000	7240
	"	"	17.73	26 000	1465	130 200	7350
	"	Hard	17.81	17 000	954	108 000	6060
	Flat	Low	23.30	21 200	910	48 750	2090
	"	Medium	24.58	22 600	920	84 900	3460
	"	"	24.50	19 425	794	99 900	4080
	"	"	25.38	23 210	918	122 930	4850
	"	Hard	23.06	22 000	955	75 500	3270
12 by 12 by 12...	Edge	Low	25.80	37 000	1433	66 250	2565
	"	Medium	25.21	21 000	833	90 150	3570
	"	"	25.71	20 000	779	86 800	3380
	"	"	23.67	7 200	304	79 400	3350
	"	Hard	25.69	21 000	817	101 500	3950
	Flat	Low	26.76	33 000	1232	83 380	3120
	"	Medium	25.50	19 500	736	113 400	4280
	"	"	25.75	14 500	564	81 750	3175
	"	"	25.20	9 000	357	96 900	3845
	"	Hard	25.23	16 400	650	95 100	3760
	End	Beyond capacity of machine.					
12 by 12 by 12...	Flat	Medium	21.90	8 000	383	69 000	3150
	"	Hard	21.05	25 000	1185	72 000	3420
	"	Medium	21.42	26 400	1230	44 000	2055
	"	"	23.40	6 000	256	95 800	4090
	Edge	Hard	22.40	12 000	536	75 200	3360
	"	Medium	22.40	7 000	312	75 000	3350
	"	"	22.40	26 000	1160	58 950	2630
	"	"	22.80	25 300	1110	57 900	2540
	"	Low	23.00	20 000	869	54 800	2380
	End	Medium	44.73	70 000	1565	199 300	4460
	"	"	43.58	65 000	1490	187 500	4310

TABLE IV.—CASE SCHOOL OF APPLIED SCIENCE TESTS (*Continued*).

Size of Specimen, in.	How Tested.	Degree of Burning.	Net Section Area, sq. in.	Load at First Crack.		Maximum Load.	
				lb.	lb. per sq. in.	lb.	lb. per sq. in.
4 by 12 by 12...	Flat	Hard	20.20	5 900	292	76 350	3780
	"	Medium	19.00	22 000	1158	63 500	3345
	"	Low	20.70	9 600	465	84 620	4080
	"	Medium	21.00	4 200	200	90 800	4320
	"	"	21.05	8 100	384	92 500	4380
	Edge	Medium	11.80	6 000	508	22 200	1880
	"	"	10.75	7 000	650	24 000	2230
	"	Low	10.45	8 000	765	33 180	3170
	"	Medium	11.45	33 400	292	12 750	1114
	"	Hard	10.35	2 700	261	18 000	1740
	End	Medium	18.08	38 700	2135	108 000	5970
	"	"	17.12	26 000	1518	122 000	7130
8 by 12 by 12...	Flat	Medium	22.10	17 500	791	60 000	2710
	"	"	20.90	17 500	835	70 450	3360
	"	"	18.40	11 000	600	59 250	3220
	"	Low	18.20	3 400	186.5	61 300	3360
	"	Hard	19.90	14 000	703	64 000	3215
	Edge	Low	20.80	8 900	428	36 480	1750
	"	Medium	21.42	11 000	513	58 000	2710
	"	"	19.90	21 700	1090	109 400	5500
	"	Hard	21.80	6 300	289	91 400	4180
	"	Medium	21.40	12 000	560	61 100	2860
	End	Medium	32.10	126 000	3920	200 000	
	"	"	32.71	143 000	4375	+200 000	

TABLE V.—COMPRESSION TESTS
MADE BY
CORNELL UNIVERSITY.
TILE FROM MARYLAND

Size of Specimen, in.	How Tested.	Degree of Burning.	Net Section Area, sq. in.	Load at First Crack.		Maximum Load.	
				lb.	lb. per sq. in.	lb.	lb. per sq. in.
4 by 12 by 12...	End	Low	17.58	24 600	1400	46 800	2660
	"	Medium	17.05	14 970	880	44 080	2590
	"	"	18.66	34 305	1840	48 405	2600
	"	"	17.79	35 000	1970	41 000	2310
	"	Hard	17.68	35 000	1980	37 500	2120
	Side	Low	10.89	11 100	1020	20 760	1906
	"	Medium	9.73	....	....	9 530	980
	"	"	9.76	3 900	400	12 345	1270
	"	"	10.12	8 100	800	10 670	1050
	"	Hard	10.52	9 650	920	12 000	1140
	Flat	Low	23.16	27 700	1200	64 300	2780
	"	Medium	21.05	14 975	710	22 490	1070
	"	"	24.70	38 070	1540	38 070	1540
	"	"	22.63	25 500	1130	25 500	1130
	"	Hard	22.29	24 400	1090	38 050	1710
8 by 12 by 12...	End	Low	35.32	115 390	3270	120 000	3400
	"	Medium	34.61	57 660	1660	114 660	3320
	"	"	33.84	66 480	1970	132 530	3920
	"	"	35.39	88 560	2500	119 900	3380
	"	Hard	35.23	60 000	1705	109 200	3100
	Side	Low	21.63	16 600	770	25 600	1180
	"	Medium	22.48	19 200	855	46 700	2070
	"	"	23.15	10 450	450	22 460	970
	"	"	22.27	14 675	660	33 100	1490
	"	Hard	21.74	14 500	670	25 450	1170
	Flat	Low	21.61	12 400	575	13 800	640
	"	Medium	22.64	9 600	425	16 950	750
	"	"	22.26	12 650	570	37 150	1670
	"	"	23.57	21 160	900	37 400	1590
	"	Hard	21.12	11 400	540	31 400	1490
12 by 12 by 12...	End	Low	51.64	80 000	1550	114 530	2220
	"	Medium	51.09	32 500	640	141 050	2760
	"	"	49.60	21 820	440	75 680	1530
	"	"	32.70	180 770	5530	221 720	6780
	"	Hard	49.32	30 500	620	113 700	2340
	Side	Low	33.56	20 500	610	24 500	730
	"	Medium	35.76	22 070	620	25 980	730
	"	"	30.35	19 700	650	49 250	1620
	"	"	32.71	32 810	1005	73 100	2240
	"	Hard	33.00	22 850	690	46 540	1410
	Flat	Low	32.10	13 100	410	23 050	720
	"	Medium	31.00	13 500	435	54 850	1770
	"	"	30.80	49 800	1620	57 250	1860
	"	"	31.00	22 040	710	64 450	2080
	"	Hard	29.60	28 050	945	67 200	2270

TABLE VI.—COMPRESSION TESTS MADE BY UNIVERSITY OF ILLINOIS.

TILE FROM ILLINOIS.

Size of Specimen, in.	How Tested.	Degree of Burning.	Net Section Area, sq. in.	Maximum Load.	
				lb.	lb. per sq. in.
4 by 12 by 12	End	Low	23.33	99 600	4 270
	"	Medium	20.96	135 000	6 450
	"	"	20.61	134 600	6 540
	"	"	21.56	135 000	6 260
	"	Hard	19.26	104 000	5 420
	"	"	20.00	101 500	5 075
	Edge	Low	15.70	32 400	2 060
	"	Medium	15.64	55 900	3 560
	"	"	16.51	53 900	3 260
	"	"	15.9	48 800	3 070
	"	Hard	14.05	50 100	3 570
	Flat	Low	32.8	151 400	4 620
	"	Medium	30.5	161 000	5 300
	"	"	31.7	163 200	5 150
	"	"	30.4	188 300	6 200
	"	Hard	27.2	207 100	7 620
6 by 8 by 12	End	Low	17.49	87 900	5 020
	"	Medium	18.54	85 400	4 610
	"	"	16.80	90 200	5 360
	"	"[1]	14.37	174 800	12 150
	"	"	16.90	97 100	5 750
	"	Hard	15.32	185 300	12 100
	Edge	Low	13.04	41 900	3 210
	"	Medium	14.55	32 800	2 260
	"	"	14.78	35 600	2 400
	"	"	14.90	42 400	2 850
	"	Hard	11.65	47 200	4 050
	Flat	Low	23.5	103 000	4 400
	"	Medium	23.4	87 200	3 730
	"	"	22.2	117 000	5 280
	"	"	22.6	115 000	5 100
	"	Hard	20.65	168 600	8 180
8 by 12 by 12	End	Low	42.7	150 000	3 500
	"	Medium	42.35	217 000	5 140
	"	"	40.40	200 000	4 950
	"	"	41.96	254 000	6 060
	"	"	38.50	169 400	4 400
	"	Hard	38.35	305 600	7 970
	Edge	Low	23.5	66 100	2 820
	"	Medium	24.4	69 400	2 840
	"	"	23.6	81 200	3 440
	"	"	23.7	113 700	4 810
	"	Hard	21.95	84 700	3 860
	Flat	Low	34.9	83 400	2 390
	"	Medium	31.7	119 000	3 760
	"	"	31.85	144 500	4 540
	"	"	31.75	118 400	3 740
	"	Hard	29.1	275 600	9 500

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[1] Probably hard burned.

TABLE VII.—COMPRESSION TESTS MADE BY THE UNIVERSITY OF PITTSBURGH.

TILE FROM NORTHWESTERN PENNSYLVANIA.

Size of Specimen, in.	How Tested.	Degree of Burning.	Net Section Area, sq. in.	Load at First Crack.		Maximum Load.	
				lb.	lb. per sq. in.	lb.	lb. per sq. in.
4 by 12 by 12....	Flat	Low	22.6	85 000	3762	88 000	3 892
	"	Medium	22.2	87 500	3942	155 160	6 985
	"	"	21.2	124 100	5850	159 900	7 550
	"	"	23.0	108 300	4715	148 750	6 470
	"	Hard	21.0	94 100	4474	172 050	8 200
	End	Low	19.1	70 000	3665	71 600	3 750
	"	Medium	19.6	95 750	4880	96 690	5 080
	"	"	18.4	117 000	6370	135 920	7 380
	"	"	18.0	110 000	6120	114 940	6 380
	"	"	17.6	88 000	5000	102 000	5 800
	"	Hard	17.7	70 000	3955	97 700	5 520
	Edge	Low	8.4	24 150	2872	28 000	3 332
	"	Medium	8.1	18 100	2263	23 180	2 896
	"	"	8.1	16 600	2050	19 650	2 427
	"	"	8.0	17 000	2125	22 400	2 800
	"	Hard	8.0	21 300	2665	30 840	3 852
8 by 12 by 12....	End	Low	30.7	133 400	4345	150 090	4 895
	"	Medium	27.4	228 000	8325	339 640	12 400
	"	"	29.2	118 900	4075	178 680	6 120
	"	"	27.6	202 000	7320	208 200	7 550
	"	"	28.1	145 000	5160	209 080	7 574
	"	Hard	25.5	168 000[a]	6590	294 380	11 550
	"	"	25.0	50 000	2000	213 500	8 542
	Flat	Low	16.4	35 350	2157	66 500	4 057
	"	"	17.1	50 000	2924	62 800	3 670
	"	Medium	16.8	31 330	1865	77 430	4 610
	"	"	16.2	77 780	4800	79 130	4 895
	"	"	16.1	53 400	3317	84 050	5 220
	"	Hard	16.1	28 500	1770	90 830	5 645
	Edge	Low	16.3	46 140	2830	54 000	3 312
	"	Medium	16.2	89 200	5500	97 870	6 045
	"	"	16.2	99 150	6120	99 150	6 120
	"	"	16.2	52 250	3230	96 410	5 950
	"	"	16.0	64 750	4040	101 200	6 325
	"	Hard	16.0	36 000	2250	96 430	6 025

[a] When strain readings were taken, was raised to 200 000 lb. without a sign of crack. Crack at 168 000 lb occurred when raised second time.

TABLE VIII.—COMPRESSION TESTS ON SPECIAL-SHAPED TILE SUCH AS H OR T SHAPE.

MADE BY
UNIVERSITY OF WISCONSIN.
TILE FROM IOWA.

Size of Specimen, in.	How Tested.	Degree of Burning.	Net Section Area, sq. in.	Load at First Crack.		Maximum Load.	
				lb.	lb. per sq. in.	lb.	lb. per sq. in.
8 by 10 by 12....	Edge	Medium	35.0	27 000	770	80 000	2 280
	“	“	35.0	43 000	1230	127 000	3 630
	“	“	33.0	43 000	1300	120 500	3 660
	“	“	35.5	25 000	700	86 000	2 420
	“	“	34.0	31 000	910	71 000	2 080
	“	“	33.5	25 000	750	88 000	2 620
	“	Hard	34.5	17 000	490	84 000	2 430
	“	“	33.5	32 000	950	96 500	2 880
	“	Low	34.0	39 000	1150	100 000	2 940
	“	“	33.5	22 000	660	84 000	2 500
	End	Medium	41.0	109 000	2660	181 000	4 410
	“	“	41.0	44 000	1070	117 000	2 850
	“	“	42.5	92 000	2240	144 000	3 380
	“	“	42.0	60 000	1430	140 000	3 330
	“	“	40.0	68 000	1700	153 000	3 820
	“	“	41.0	108 000	2630	146 000	3 560
	“	Hard	42.0	30 000	710	103 000	2 450
	“	“	41.0	92 000	2240	156 000	3 800
	“	Low	40.0	100 000	2500	156 000	3 900
	“	“	40.0	36 000	900	122 000	3 050
4 by 12 by 10....	End	Medium	35.0	130 000	3720	137 000	3 020
	“	“	35.0	152 000	4320	152 000	4 320
	“	“	33.0	84 000	2540	135 000	4 090
	“	“	34.0	75 000	2200	163 000	4 800
	“	Hard	33.5	81 000	2420	184 000	5 490
	“	“	34.5	70 000	2020	107 000	3 100
	Side	Medium	53.0	160 000	3020	237 000	4 480
	“	Hard	50.0	200 000	4000	+583 000	+11 660

APPENDIX II.

ABSORPTION TESTS OF TILE.

Number and Selection of Samples.—The tile selected for absorption tests shall be the nine specimens on which the stress-strain readings are taken (see Table II under "Instructions for Physical Tests," Appendix I).

Not less than three pieces, chosen after breaking in compression test, shall be selected from each of the above tiles, to constitute a sample for absorption tests. Two of the three pieces shall be taken from opposite ends of the specimen and different webs, and one from the middle portion. The pieces shall be approximately square and range from about 12 to 20 sq. in. area of face, and shall not show cracks or fissures from the breaking in compression test. The specimens shall be marked so as always to preserve the identity in respect to the particular type of tile and degree of burning, as denoted by the respective marks, "L," "M" and "H," on specimens before breaking.

Drying Specimens.—Preparatory to the absorption test, all specimens shall be first weighed and then dried in a drier or oven at a temperature of not less than 110° C. (230° F.) for not less than three hours. After removal from the drier, the specimens shall be allowed to cool to a temperature of 20 to 25° C. (68 to 77° F.) and reweighed. If the specimens were apparently dry when taken, and the second weight closely checks the first, the specimen shall be considered dry. If the specimens were known to be wet when taken, they shall be placed in the dryer for a further drying treatment of two hours, and reweighed. If the third weight does not check the second the specimen must be redried for two-hour periods until check weights are obtained.

Weighing and Reweighing.—The balance used shall be sensitive to 0.5 gram when loaded with one kilogram, and weighings shall be read at least to the nearest gram. Where other than metric weights are used, the same order of accuracy must be obtained.

In reweighing after immersion, the specimens shall be removed from the water, allowed to drain not more than one minute, the superficial water removed by towel or blotting paper, and the specimen at once put upon the balance.

Immersion of Specimens.—Specimens after weighing shall be placed in a suitable woven-wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rain water, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15° C. (50 to 59° F.).

Calculation and Reporting of Results.—The results shall be calculated in percentages of the initial dry weight, carried to the nearest first decimal place.

TABLE I.—ABSORPTION TESTS
MADE BY
THE BUREAU OF STANDARDS.[1]
TILE FROM OHIO.

Size of Original Tile, in.	Net Section Area, sq. in.	Weight, lb.	Maximum Load.		Absorption per cent.
			lb.	lb. per sq. in.	
4 by 5 by 12	10.9	9.25	58 950	5 420	6.7
	10.6	9.12	68 000	6 420	8.6
4 by 12 by 12	20.8	19.40	166 000	7 980	6.1
	22.8	19.60	177 300	7 780	6.0
	22.3	19.38	158 430	7 100	6.2
6 by 12 by 12	37.6	32.70	376 000	10 000	3.8
	38.8	31.65	284 000	8 400	5.1
	37.6	31.70	335 500	8 920	3.8
8 by 12 by 12	44.7	36.80	284 000	6 350	10.4
	42.7	37.20	374 200	8 770	8.7
	42.7	35.65	227 600	5 330	10.9
12 by 12 by 12	44.2	39.50	396 300	8 980	6.3
	46.6	40.15	362 700	7 780	6.3
	45.5	39.90	352 500	7 750	7.8
	56.6	49.30	341 800	6 040	8.7

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[1] These tests, made according to program, except the absorption tests, are not correlated with the compression tests as provided in program. The samples however, were selected from the same lot furnished for tests. The investigation was started before the work of Committee C-10 was organized.

TABLE II.—ABSORPTION TESTS MADE BY CORNELL UNIVERSITY.

TILE FROM MARYLAND.

Size of Original Tile, in.	Degree of Burning.	Average Dry Weight, g.	Wet Weight, g.	Absorption, per cent.
4 by 12 by 12	Low	311.21	344.62	10.74
	"	215.12	237.26	10.29
	"	532.59	595.20	11.78
	Medium	194.50	226.33	16.37
	"	181.42	213.36	17.59
	"	150.09	176.29	17.46
	Hard	377.10	403.00	6.87
	"	492.80	531.30	7.82
	"	370.00	397.30	7.38
8 by 12 by 12	Low	237.88	254.00	6.77
	"	199.30	211.20	5.97
	"	244.08	260.40	6.68
	Medium	401.20	438.30	9.25
	"	245.00	268.10	9.44
	"	241.61	265.40	9.84
	Hard	367.76	398.10	8.25
	"	263.25	284.19	7.45
	"	287.10	312.12	8.72
12 by 12 by 12	Low	371.60	395.00	6.30
	"	296.10	315.00	6.38
	"	340.34	359.60	5.66
	Medium	427.13	460.63	7.84
	"	360.74	388.71	7.75
	"	252.38	270.53	7.19
	Hard	328.15	353.40	7.69
	"	556.60	596.45	7.17
	"	463.25	499.97	7.93

TABLE III.—ABSORPTION TESTS
MADE BY
UNIVERSITY OF ILLINOIS.

TILE FROM ILLINOIS.

Size of Original Tile, in.	Degree of Burning.	Average Dry Weight, g.	Wet Weight, g.	Absorption, per cent.
12 by 12 by 12	Low	438.0	524.0	19.6
	"	495.7	596.5	20.3
	"	321.0	384.0	19.6
	"	321.2	382.5	19.1
	"	336.0	399.5	18.9
	Medium	362.2	400.5	10.6
	"	192.3	216.7	12.7
	"	275.1	307.5	10.8
	"	292.8	328.5	12.2
	"	110.5	123.7	12.0
	Medium	305.1	338.5	11.0
	"	290.5	322.5	11.0
	"	349.5	384.0	9.9
	"	251.5	277.5	10.3
	"	221.0	247.5	12.0
	Medium	263.0	294.5	12.0
	"	365.5	410.0	12.2
	"	312.7	350.0	11.9
	"	147.0	164.7	12.0
	"	247.5	278.0	12.3
	Hard	338.0	344.0	1.8
	"	255.0	260.5	2.2
	"	244.2	250.5	2.6
	"	233.6	238.0	1.9
	"	239.0	244.0	2.1
	Hard	549.5	563.0	2.5
	"	692.0	707.5	2.2
	"	643.0	659.5	2.6
6 by 8 by 12	Low	567.0	658.0	16.1
	"	264.3	306.5	16.0
	"	532.0	619.5	16.5
	Medium	283.5	315.5	11.3
	"	297.2	331.5	11.5
	"	307.8	345.0	12.1
	"	431.5	483.2	12.0
	"	394.5	441.5	11.9
	Medium	303.0	337.0	11.2
	"	508.2	560.5	10.3
	"	259.8	288.7	11.1
	"	176.0	195.5	11.1
	"	376.3	414.5	10.2
	Medium[1]	357.5	375.0	4.9
	"	263.8	275.0	4.2
	"	207.5	214.0	3.1
	"	272.8	283.0	3.7
	Medium	390.3	431.5	10.6
	"	515.7	567.0	10.6
	"	785.3	864.5	10.1
	"	212.3	234.5	10.5
	Hard	203.8	208.5	2.3
	"	287.7	295.0	2.5
	"	236.8	243.0	2.6
	"	180.0	185.0	2.8
	"	191.0	195.0	2.1

[1] Probably hard burned.

TABLE III.—UNIVERSITY OF ILLINOIS TESTS (*Continued*).

Size of Original Tile, in.	Degree of Burning.	Average Dry Weight, g.	Wet Weight, g.	Absorption, per cent.
8 by 12 by 12..............................	Low	475.9	559.0	17.5
	"	1386.0	1610.0	16.2
	"	434.0	507.0	16.8
	"	376.4	442.5	17.6
	"	266.4	314.5	18.1
	Medium	313.6	361.5	15.3
	"	297.5	340.0	14.3
	"	168.5	194.5	15.4
	"	227.0	261.0	15.0
	"	239.5	274.5	14.6
	Medium	621.0	696.6	12.2
	"	257.0	288.0	12.0
	"	405.6	457.5	12.8
	"	396.5	444.0	12.0
	Hard	252.6	274.5	8.7
	"	400.3	434.0	8.4
	"	595.3	641.5	7.8
	"	416.3	454.5	9.2
	"	294.5	319.0	8.3

TABLE IV.—ABSORPTION TESTS
MADE BY
UNIVERSITY OF WISCONSIN.
TILE FROM IOWA.

Size of Original Tile, in.	Degree of Burning.	Absorption, per cent; Piece No.			Average Absorption for Tile, per cent.
		1	2	3	
8 by 10 by 12............	Low	9.8	8.9	....	9.4
	Medium	13.7	14.9	15.0	14.5
	"	12.1	12.6	12.8	12.5
	Hard	15.7	16.7	14.7	15.7
4 by 12 by 10............	Medium	13.5	13.6	12.9	13.3
	Hard	8.4	8.3	7.5	8.1

TABLE V.—ABSORPTION TESTS
MADE BY
THE UNIVERSITY OF PITTSBURGH.
TILE FROM NORTHWESTERN PENNSYLVANIA.

Size of Original Tile, in.	Degree of Burning.	Average Dry Weight, g.	Wet Weight, g.	Absorption, per cent.	Average Absorption, per cent.
8 by 12 by 12	Medium	307.66	332.89	8.2	8.1
	"	231.89	251.18	8.3	
	"	367.59	396.65	7.9	
	Medium	296.21	322.25	8.8	8.8
	"	267.07	290.30	8.7	
	"	241.48	262.78	8.8	
	Low	267.47	299.00	11.8	11.8
	"	251.49	280.31	11.5	
	"	212.38	238.07	12.1	
	Hard	441.07	465.59	5.5	5.3
	"	337.37	356.41	5.6	
	"	481.73	505.42	4.9	
4 by 12 by 12	Medium	232.60	255.48	9.8	9.7
	"	251.57	276.00	9.6	
	"	341.29	373.81	9.5	
	Medium	224.97	247.09	9.8	9.4
	"	309.62	339.13	9.5	
	"	241.90	263.45	8.9	
	Low	203.27	232.07	14.2	13.6
	"	251.03	285.44	13.7	
	"	379.56	417.64	13.0	
	Hard	332.28	348.46	4.9	4.7
	"	206.99	213.99	3.4	
	"	283.18	299.41	5.7	

AVERAGES.

Hard	5.0
Medium	9.0
Low	12.7

APPENDIX III.

TESTS OF TILE WALLS.

General Instructions and Specifications for Tests.

The wall tests are classified under five series as later specified. When practicable, three tests of a type are to be made for determining the average mechanical properties of the walls. The question of the number of the individual tests, however, also any special grouping of the walls of the series is to be arranged by the cooperating laboratory and manufacturer, subject to the approval of Committee C-10 through its chairman.

Sampling of Tiles.—Tiles are to be of a grade such as would conform to good commercial and building practice, without reference to degree of burning. Add about 5 per cent of the number required in each wall for contingencies of breaking, and making tests on tile where desirable.

Series I: Compression Tests; Flues Vertical in Walls.—Height of walls shall be 12 ft. 0 in. over all if possible.

Width of wall may be 3 ft. 0 in. up to 6 ft. 0 in. according to the size of available testing machines, and at the option of the manufacturer.

Thickness of walls shall be 6 in., 8 in. and 12 in. in a full series, but a single thickness either 8 or 12 in. will be tested when the manufacturer desires to submit one or more walls, rather than the complete series.

Mortar in laying: 1 : 3 Mixture as follows:

$$\left.\begin{array}{l}\text{1 cu. ft. Portland cement}\\ \tfrac{1}{4}\text{ cu. ft. hydrated lime}\end{array}\right\}+3\text{ cu. ft. of sand}$$

$$\text{Equals:--}\left.\begin{array}{l}\text{94 lb. of Portland cement}\\ \text{10 lb. of hydrated lime}\end{array}\right\}+300\text{ lb. of sand.}$$

Thickness of Joints: Average thickness = $\frac{3}{8}$ in. Tile shall be thoroughly wet before laying.

Age of Walls: One month (variation 28 to 32 days permitted).

Stress-Strain Readings: Record compression readings by suitable full length extensometers at corners of walls, also lateral deflections of wall, if any. The number and position of portable extensometer readings on the faces of wall will be discussed with the cooperating laboratories in the preliminary arrangements for tests.

Series II: Compression Tests; Flues Horizontal in Walls.—A repetition of tests under specifications for Series I is made, except that tile are to be laid with flues horizontal to axis of wall instead of vertical.

Series III: Eccentric Loads in Compression.—A certain number of tests will be arranged in which the walls are laid according to the specifications of Series I and II, but in which the load is applied at the top eccentrically to the axial plane of walls, strain measurements being taken as before. The eccentric application of load is planned to approximate the conditions of floor and joist loadings in construction practice. A narrow continuous strip or blunt knife edge will be placed between suitable distributing plates on top of wall and upper platen of testing machine, and set at different distances from the axial plane. Details will be arranged after further discussion with cooperating manufacturers and laboratories.

Series IV: High Walls.—Walls of height 12 to 20 ft., otherwise according to specifications and measurement of Series I and II, will be tested when desired by manufacturers and appropriate testing machines are available for the tests.

Series V: Transverse Tests.—Transverse tests on tile walls have been made in a number of instances, the walls being placed vertical with supporting lateral abutments at top and bottom. A transverse force at mid-height of wall, and distributed over the width of wall, is applied through the medium of a calibrated pressure-jack or other suitable dynamometer, and continued to destruction of wall, appropriate measurements being made. Committee C-10 did not recommend these tests, but will endeavor to supervise them when requested by manufacturers, and suitable arrangements can be made with cooperating laboratories.

In the following tables are given the results of wall tests made by the Department of Applied Mechanics of the University of Toronto on tile from Toronto:

TABLE I.—WALL TEST NO. 1.

WALL: HEIGHT, 5 FT. 7 IN.; WIDTH, 3 FT. 0½ IN.; THICKNESS, 8⅛ IN.; AGE, 42 DAYS.
ALL LOADS APPLIED WITHOUT ECCENTRICITY. ALL WALLS HAVE FLUES HORIZONTAL.

Load, lb.	Compression, in.; Corner No.					Lateral Deflection, in., at Distances from Top of				
	1	2	3	4	Mean.	9 in.	20 in.	32 in.	44 in.	55 in.
5 000	+0.016	+0.007	−0.005	−0.012	+0.0015	....	....	0	....	....
10 000	0.033	0.014	+0.005	+0.021	0.0180	....	....	0	....	....
15 000	0.040	0.013	0.005	0.025	0.0208	....	....	0	....	....
20 000	0.045	0.016	0.010	0.026	0.0242	....	....	0	....	....
30 000	0.046	0.016	0.012	0.032	0.0265	0	0	0	0	0
40 000	0.050	0.019	0.022	0.038	0.0322	0.03	0.05	0.04	0.02	0.00
50 000	0.053	0.023	0.023	0.042	0.0352	....	....	0.05	....	....
60 000	0.053	0.027	0.029	0.046	0.0388	....	....	0.05	....	....
70 000	0.056	0.028	0.034	0.049	0.0418	....	....	0.05	....	....
80 000	0.058	0.028	0.042	0.052	0.0450	....	....	0.06	....	....
90 000	0.061	0.029	0.047	0.054	0.0478	....	0.10	0.07	0.03	Cracks.
95 000	0.064	0.028	0.053	0.055	0.0500	....	....	0.06	....	....
100 000	.....	.....	0.057	0.057	......	....	....	0.11	....	Rupture.

TABLE II.—WALL TEST NO. 2.

WALL: HEIGHT, 5 FT. 6¾ IN.; WIDTH, 3 FT. 0¼ IN.; THICKNESS, 8 IN.; AGE, 42 DAYS.
ALL LOADS APPLIED WITHOUT ECCENTRICITY. ALL WALLS HAVE FLUES HORIZONTAL.

Load, lb.	Compression, in.; Corner No.				Deflection, in.		Remarks.
	1	2	3	4	1–2	3–4	
300	−0.002	−0.001	+0.002	+0.004	....	....	Cracks were noticed at 100 000-lb. load; failure at 120 000-lb. load.
10 000	+0.024	+0.002	0.007	0.004	....	....	
20 000	0.040	0.010	0.018	0.049	....	....	
30 000	0.049	0.017	0.027	0.056	....	....	
40 000	0.058	0.023	0.036	0.061	....	....	
50 000	0.064	0.029	0.042	0.065	....	....	
60 000	0.070	0.032	0.048	0.070	....	....	
70 000	0.077	0.039	0.053	0.075	....	....	
80 000	0.082	0.042	0.059	0.079	−0.01	+0.02	
90 000	0.088	0.049	0.065	0.082	0.01	0.02	
100 000	0.095	0.054	0.079	0.087	0.01	0.02	
110 000	0.101	0.060	0.078	0.090	0.02	0.03	
120 000	.....	.....	.....	.....	....	....	

TABLE III.—WALL TEST NO. 3.

WALL: HEIGHT, 5 FT. 7½ IN.; WIDTH, 3 FT. 0 IN.; THICKNESS, 12¼ IN.; AGE, 38 DAYS.
ALL LOADS APPLIED WITHOUT ECCENTRICITY. ALL WALLS HAVE FLUES HORIZONTAL.

Load, lb.	Compression, in.; Corner No.				Lateral Deflection, in.[1]	
	1.	2.	3.	4.	East.	West.
10 000	0.018	0.006	−0.005	0.020	1.82	1.8
20 000	0.025	0.012	+0.021	0.030	1.83	1.8
30 000	0.035	0.020	0.029	0.034	1.83	1.8
40 000	0.041	0.027	0.033	0.040	1.83	1.8
50 000	0.045	0.031	0.037	0.041	1.84	1.79
60 000	0.053	0.033	0.041	0.044	1.84	1.79
70 000	0.056	0.038	0.046	0.046	1.84	1.79
80 000	0.062	0.042	0.047	0.050	1.84	1.79
90 000	0.063	0.048	0.052	0.052	1.84	1.79
100 000	0.069	0.048	0.058	0.055	1.84	1.79
110 000	0.074	0.055	0.057	0.056	1.84	1.79
120 000	0.078	0.058	0.059	0.060	1.82	1.79
130 000	0.083	0.059	0.060	0.062	1.82	1.79
140 000	0.083	0.064	0.064	0.064	1.78	1.79
150 000	0.090	0.065	0.064	0.064	1.78	1.78
160 000	0.095	0.070	0.068	0.067	1.78	1.77
170 000	0.098	0.070	0.068	0.070	1.78	1.78
180 000	0.104	0.075	0.070	0.075	1.80	1.77
190 000	.....	.....	.....	.....	....	....
Zero	Zero	Zero	Zero	Zero	1.82	1.80

[1] Lateral deflection is the difference between these two columns.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

Committee D-1 on Preservative Coatings for Structural Materials, which now has 86 members, has held two meetings since the last annual meeting of the Society. At the meeting held November 22, 1916, 28 members were present, and at the meeting held April 13, 1917, 39 members were in attendance.

The committee recommends that the following tentative standards be submitted to letter ballot for adoption as standard:

1. Tentative Methods for Routine Analysis of White Pigments, first published in 1915 and then in 1916.[1]

2. Tentative Tests for Paint Thinners Other Than Turpentine, of which the distillation tests have been published since 1915 and the specific gravity test since last year.[2]

3. Tentative Tests for Shellac,[3] consisting of (*a*) Determination of Rosin in Shellac and (*b*) Determination of Insoluble Matter in Shellac, both published since 1914, and (*c*) Determination of Moisture in Bleached Shellac published since 1915.

The committee recommends that the following methods for analysis be published as tentative, with the understanding that the first will be submitted to letter ballot for adoption in 1918.

1. Methods for Routine Analysis of Dry Red Lead[4] published in 1914.

2. Methods for Routine Analysis of Yellow, Orange, Red and Brown Pigments containing Iron and Manganese reported by Sub-Committee VIII on Methods of Analysis of Paint Materials.

Reports are appended from the following sub-committees:

Sub-Committee III on Testing of Paint Vehicles;
Sub-Committee V on Linseed Oil;

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 536 (1916).

[2] *Ibid.*, p. 518.

[3] *Ibid.*, p. 522.

[4] *Ibid.*, Vol. XIV, Part I, p. 281 (1914).

Sub-Committee VIII on Methods of Analysis of Paint Materials;

Sub-Committee IX on Varnish;

Sub-Committee XI on Paint Thinners Other Than Turpentine;

Sub-Committee XIV on Preparation of Iron and Steel Surfaces for Painting;

Sub-Committee XV on Specifications for Pigments Dry and in Oil when Marketed in the Form;

The following sub-committees report progress:

Sub-Committee VI on Definitions of Terms used in Paint Specifications;

Sub-Committee VII on Accelerated Tests and the Influence of Paint Materials on Corrosion;

Sub-Committee XII on Turpentine;

Sub-Committee XIII on Shellac;

Sub-Committee XVI on Terms Used in Reporting the Condition of Painted Surfaces;

Sub-Committee XVII on Testing of Pigments for Fineness by the Use of Screens;

Sub-Committee XVIII on Physical Properties of Paint Materials.

This report has been submitted to letter ballot of the committee, which consists of 87 members; 54 ballots were cast, 33 not voting. The vote was taken on each section of the report. Following is the result of the ballot:

General Report..............	50	affirmative	0	negative
Report of Sub-Committee III.	48	"	0	"
Report of Sub-Committee V...	46	"	0	"
Report of Sub-Committee VIII	46	"	0	"
Report of Sub-Committee IX.	44	"	1	"
Report of Sub-Committee XI.	44	"	0	"
Report of Sub-Committee XIV	47	"	0	"
Report of Sub-Committee XV.	42	"	3	"

Respectfully submitted on behalf of the committee,

P. H. WALKER,
Chairman.

G. W. THOMPSON,
Secretary.

EDITORIAL NOTE.

For Addendum to this Report, see page 460.

REPORT OF SUB-COMMITTEE III ON TESTING OF PAINT VEHICLES.

The work of the sub-committee during the past year has consisted largely of an investigation of lumbang and perilla oils supplied to the members from a quantity that was crushed from seed imported by the Educational Bureau of the Paint Manufacturers' Association of the United States. The reports of the various analysts participating are given in Appendix I. It is felt that these newer oils may find important applications in the paint and varnish industry and that the results of the work appended herewith will be of service to the users, and later on will possibly serve as a working basis upon which standards for purity may be developed.

A request was made that the U. S. Department of Commerce obtain a Consular report on lumbang and perilla oils. As a result a preliminary report has been received and is given in Appendix II.[1]

The sub-committee feels the successful result of the tests, as well as the satisfactory results reported by Paint Manufacturers Association on the use of several hundred barrels of perilla oil, would warrant the importation of the oil in larger quantities.

Respectfully submitted on behalf of the sub-committee,

H. A. GARDNER,
Chairman.

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[1] For information on the development of the Philippine lumbang industry, reference can be made to Commerce Reports No. 89, April, 1917.

APPENDIX I.

REPORTS OF ANALYSTS ON LUMBANG AND PERILLA OILS.

REPORT OF H. A. GARDNER.

LUMBANG OIL.

Description.—This oil is obtained from the fruit of a tree known as *Aleurites moluccana*, indigenous to Polynesia and now widely cultivated in certain parts of Asia as well as in tropical islands—Hawaii and the Philippines. Experiments have shown that the tree also flourishes on the Florida peninsula and certain parts of the Gulf coast. It is of the same family as the tung tree, and the oil closely resembles tung oil in analytical constants, but does not have the peculiar properties of polymerization shown by the latter. Its constitution is, moreover, different from that of tung oil. The tree is a highly ornamental shade tree, growing to a height of 30 or 40 ft., widely spreading its branches and producing large, glossy leaves. It bears two heavy crops of fruit, which contain the so-called lumbang nuts. These consist of heavy shells containing a light-colored kernel or meat rich in oil. The kernels burn freely with a sooty flame, and are often used as a source of illumination by the natives, thus acquiring the local name of candle nuts. The nuts have a pleasant taste, resembling Brazil nuts. The oil from the nuts is almost colorless and has a purgative action. This would indicate that the oil might find a use in medicine, and would suggest further experiments.

When the nuts are pressed for the oil content, a press cake is left which is highly prized by the natives for its fertilizing action, a price of $100 a ton being paid for it in preference to ground fish or tankage at $25. The natives apparently are successful in producing a most remarkable stimulus of growth in certain plants through its use. The chemical analysis of the press cake shows a very considerable amount of valuable plant foods, which probably are in a readily assimilable form. The oil is marketed in Manila and is used there in the crude manufacture of soap, painting of river craft, etc.

The difficulty in obtaining very large amounts of the oil lies in the present unsatisfactory method of getting the kernels out of the shells. This work is done by the natives in a very crude way, the seeds being crushed by hand on rocks and the meats cut out with knives, since they adhere tenaciously to the sides of the shells. Working on a shipment of 576 lb. of the nuts imported from Hawaii, the writer proceeded as follows:

The nuts were first passed through a Chipmunk crusher, breaking them into small pieces. They were then screened in order to separate the larger pieces of meat. The small particles of meats left in the shells were picked out by hand. A portion of the meats or kernels was then cold-pressed, after they were placed in a canvas bag suspended in an apparatus made of a number of rigid iron slats banded together and welded into a plate base. Into this apparatus was inserted a metal plunger attached to a testing machine. An improved apparatus was later used, which consisted of a curb made of a 6-in. extra-heavy iron pipe 15 in. in length. One end was threaded and capped, and a large number of holes were drilled in the sides for oil exit. A plunger machined to fit snugly into the curb was provided, and the whole apparatus set in a receiving pan in the testing machine where a pressure of 150,000 lb. to the square inch was obtainable. A practically colorless oil was produced.

Before pressing the remainder of the seed, it was thought desirable to remove the small pieces of cracked shell remaining in the meats. A flotation method was developed, which it was thought might prove practicable for the rapid and complete separation of the meats from the cracked shells, as the broken nuts were delivered from the crusher. The mixture of meats and shells were therefore placed, in successive quantities, in a tub of water in which there was dissolved 5 per cent of table salt to increase its specific gravity. The cracked shells fell to the bottom and the oily meats floated on the surface of the salt solution, from which they were removed and dried. The separation was rapid and complete. Unfortunately, however, the meats absorbed a considerable amount of the salt solution and during drying, partial hydrolysis of the oil in the meats occurred. Moreover, the water acted as an extractive upon the cracked shells and took into solution a large amount of a brown, tannin-like dye that discolored the oil in the seed. When the dried meat was pressed, the oil obtained was therefore dark in color. This hydrolyzed lumbang oil was very turbid. Its acid number was 54.2. The fatty acids were extracted from some of this oil and their neutralization value (acid number) was found to be 197.7, and iodine number 147.6. These fatty acids were liquid and of a clear orange color.

Data on the pressing of the lumbang nuts and analysis of the press cake and oil are given herewith.

The analysis of lumbang nuts was as follows:

Average weight of nut, g	11.7
Shells, per cent	67.9
Kernels, per cent	32.1
Oil in shells (ex.), per cent	0.6
Oil in kernels (ex.), per cent	60.3
Ash of kernel, per cent	3.2
Nitrogen in kernel, per cent	3.2

The press cake from cold pressing was thoroughly extracted with benzine to remove any oil present and then dried. The analysis of the dried press cake showed the following values:

Nitrogen, per cent	7.34
Phosphoric anhydrid, per cent	3.95
Soda (Na_2O), per cent	0.47
Potash (K_2O), per cent	1.42

The analysis of cold-pressed lumbang oil was as follows:

	SEPT., 1916.	JAN., 1917.
Specific gravity	0.927	0.930
Acid number	1.3	1.6
Iodine number	162.0	160.6
Saponification number	192.3	191.3
Refractive index	1.475	1.4762

Weighed glass plates were coated with raw lumbang oil and with boiled lumbang oil containing 0.5 per cent of lead and manganese oxides in solution. The oxygen absorption shown when the oils became thoroughly dry are as follows:

Raw lumbang oil, 6 days, per cent	19.8
Boiled lumbang oil, 2 days, per cent	13.1

PERILLA OIL.

Nearly 1000 lb. of perilla seed[1]—the small round seed of *Perilla nankinensis*—a plant grown extensively in China and Japan, was imported from Yokohama and received early in September, 1916. For crushing tests, permission was obtained from the Department of Agriculture to use their half-size commercial oil press. The seed was fed in at one end and carried by screw to the pressure die, where the oil was expelled, leaving the press cake. The oil obtained was of fairly light color and clear. The following data were recorded on the crushing of four barrels of seed:

Oil in seed (ex.), per cent	33.73
Cake residue, per cent	66.27

The press cake from the seed was thoroughly extracted with benzine and the cake dried and examined. The following results were obtained:

Nitrogen, per cent	5.28
Phosphoric anhydrid, per cent	2.58
Soda (Na_2O), per cent	0.56
Potash (K_2O), per cent	1.50

The analysis of perilla oil was as follows:

	SEPT. 1916.	JAN. 1917.
Specific gravity	0.937	0.939
Acid number	4.3	9.5
Iodine number	193.3	195.0
Saponification number	193.4	190.9
Refractive index	1.4780	1.4781

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[1] A high germination test (84 per cent in 6 days) having been reported on a sample of this seed sent to the Bureau of Plant Industry of the U. S. Department of Agriculture, it was decided to send a sufficient amount of the seed for large sized planting tests to Agricultural Experiment Stations in each State, so that information might be obtained as to the best climate for growing the perilla plant in this country.

Weighed glass plates were coated with raw perilla oil and with boiled perilla oil containing 0.5 per cent of lead and manganese oxide in solution. The oxygen absorption shown for the same period of time as recorded for the lumbang oil, is as follows:

Raw perilla oil, 6 days, per cent	20.3
Boiled perilla oil, 2 days, per cent	17.0

Plant Introduction.—Small quantities of two grades of perilla seed have been sent to the State Agricultural Experimental Stations throughout the United States for growing tests during the coming year. The seed from the plants will be crushed by the sub-committee for future tests.

REPORT OF J. W. KELLOGG.

Following are the results of analyses of samples of lumbang and perilla oils with their respective cakes, which were recently submitted:

	LUMBANG OIL.	PERILLA OIL.
Specific gravity at 15°.5/15°.5 C	0.9278	0.9342
Acid number	0.84	9.89
Iodine number after standing one-half hour	158.3	192.3
Saponification number	195.2	195.2
Refractive index at 25° C	1.4649	1.4689

	LUMBANG OIL CAKE (*Feeding Stuff*).	PERILLA OIL CAKE (*Feeding Stuff*).
Moisture, per cent	7.60	5.50
Protein, per cent	51.75	32.06
Fat, per cent	12.44	9.58
Fiber, per cent	4.76	16.88
Ash, per cent	9.10	10.23
Nitrogen Free Extract, per cent	14.35	25.75

	LUMBANG OIL CAKE (*as Fertilizer*).	PERILLA OIL CAKE (*as Fertilizer*).
Total Nitrogen, per cent	8.28	5.13
Insoluble Nitrogen, per cent	7.68	4.65
Nitrogen by Alkaline Permanganate, per cent	0.35	0.48
Moisture, per cent	7.60	5.50
Phosphoric Acid, per cent	1.02	0.48
Total Potash, per cent	1.56	1.11

REPORT OF G. D. WHITE AND T. R. COLLINS.

Examination of the lumbang and perilla oils showed the following average results on the determination of their constants:

	LUMBANG OIL.	PERILLA OIL.
Specific Gravity at 15°.5/15°.5 C	0.926	0.935
Acid number	1.50	12.0
Iodine number	168.0	187.0
Saponification number	188.0	188.0

REPORT OF L. P. NEMZEK.

The work included an exposure test on a varnish containing perilla oil. In this test the perilla oil was tested out in a rosin-tung oil-linseed oil varnish of only fair quality. A varnish of this type was selected so as to be able to get quick results on the substitution of perilla oil for linseed oil. The two oils were present in the proportion of three gallons of tung oil to 1.5 gal. of linseed or perilla oil.

The process by which these varnishes were made is as follows:

Rosin was melted and limed, and then the oil added. The temperature of the melt was raised to 500° F., after which it was removed from the fire and lead drier added in the form of litharge. The tung oil was then added and the temperature run up to 575° F. A temperature varying from 575 to 600° F. was maintained for about one-half hour. Borate of manganese was then added, after which the melt was permitted to cool to about 350° F. At this temperature, the volatile matter, consisting of mineral spirits, was added, and the mass thoroughly stirred and allowed to cool.

The varnishes were applied to panels and exposed to the weather. There was no noticeable difference in the working qualities of the two varnishes. They possessed about the same setting-up and drying properties, and the perilla-oil varnish, if anything, discolored less than the linseed-oil varnish. There was no difference in the varnishes for gloss qualities. The perilla-oil varnish did not develop the characteristic checking and powdering nearly as soon as the linseed-oil varnish, and gave much better results throughout the test.

The following are the chemical constants which were determined on the sample of perilla oil by Mr. J. E. Heckel:

Specific gravity at	23°.5/23°.5 C	0.9290
	15°.5/15°.5 C	0.9344
Coefficient of expansion		0.00065
Acid number		12.5 12.6 12.6
Average		12.6

Iodine number	201.1 200.0
Average	200.6
Saponification number	192.0 191.6
Average	191.8

Report of R. W. Lindsay.

The analyses of the oils gave the following values:

	Perilla Oil.	Lumbang Oil.	Hydrolized Lumbang Oil.
Specific gravity at 15°.5/15°.5 C.	0.932	0.926	0.925
Acid number	12.31	1.43	54.24
Iodine number (Hanus)	199.8	165.2	164.0
Saponification number	191.6	191.0	195.2
Refractive index at 25° C.	1.4794	1.4761	1.4739

Report of G. W. Thompson and C. B. Mills.

The results of analyses of lumbang oil are as follows:

		No. 1, Cold-Pressed.	No. 2, Hydrolized.
Specific gravity at 15°.5/15°.5 C.		0.9286	0.9270
Acid number		1.12	54.50
Iodine number	(Hanus)	164.1	164.5
	(Hübl, 6 hr.)	165.3	163.8
Saponification number		193.4	193.7
Refractive index at 25° C		1.4775	1.4761
Loss at 105° C., per cent		0.016	Slight gain
Livache test, per cent		9.48	11.02
Maximum gain on glass, per cent		13.52	15.37

REPORT OF F. A. WERTZ.

	LUMBANG.	PERILLA.
Color	Practically water white	Light greenish-yellow.
Odor	Very slight, sweet	Sweet
Appearance	Clear	Clear
Specific gravity at 15°.5/15°.5 C	0.9285[a] 0.9287[a]	0.9345[a] 0.9346[b]
Average	0.9286	0.9345
Acid number	....	12.5 12.5
Average	....	12.5
Saponification number	191.5 190.3 191.5	191.5 191.3 191.6
Average	191.1	191.5
Unsaponifiable matter[c] soluble in ether	....	0.74 0.74
Average	....	0.74
Refractive index at 25° C	1.4764[d] 1.4766[e]	1.4807[d] 1.4805
Iodine number (Hanus)	165.2 165.2	199.6 199.8
Average	165.2	199.7
Ash, per cent	....	0.01 0.01
Average	....	0.01

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[a] Determined with a pyknometer at 15°.5 C.

[b] Determined with a plummet at room temperature (25° C.) and result calculated by use of factor 0.00069 for each degree Centigrade.

[c] Boehmer method using NaOH and 25 g. of oil.

[d] Determined at 21°.4 C. and calculated to 25° C. using the factor 0.000372 for each degree Centigrade.

[e] Determined at 25°.0 C.

These determinations were made by the methods outlined under the standard specifications of the Society for Purity of Raw Linseed Oil from North American Seed.[1]

Drying Tests.—Films of oil weighing approximately 0.2 g. were brushed out to cover areas of approximately 8 by 10 cm. on 10 by 12 cm. ground-glass plates, and the gain in weight determined at intervals of 24 hr. The perilla and especially the lumbang oil showed a marked tendency to crawl over the whole surface of the plate and pile up near the edges, thus producing a film of uneven thickness. In an effort to prevent this, smaller quantities of oil, approximately 0.13 g., were brushed out to cover the same area on plates with a more coarsely ground surface, but the tendency to produce a film lacking uniformity of thickness persisted. In an attempt to explain this behavior of the perilla oil, which gave a clear continuous film when allowed to dry on plates set at an angle, viscosity measurements were made at room temperature with a MacMichael instrument. These measurements showed that the perilla oil had a somewhat lower viscosity than raw linseed oil No. 1, but it is believed that the difference was not great enough to account for the "crawling" of the perilla oil.

The results of the weight determinations are as follows:

Oil.	Average Thickness of Films, cm.			
	0.0026		0.0017	
	Maximum Gain in Weight, per cent.	Time, days.	Maximum Gain in Weight, per cent.	Time, days.
Lumbang	13.0	7	12.4	
Perilla	17.6	4	15.8[b]	2
Perilla[a]	16.3	3	....	..
Raw Linseed, No. 1	15.5	9	15.9	7
Raw Tung, No. 4	13.0	4	....	..

[a] Sample of the oil was heated rapidly to 250° C. and held there for ten minutes.

[b] This figure is probably not a true maximum, a determination of which evidently requires more frequent weighing than every 24 hr. when the oil is in very thin films, and oxidation proceeds more rapidly.

To obtain time of drying, the oils were flowed on clean glass plates placed at an angle of 30 deg. to the vertical and exposed at room temperature. The raw and heated perilla oils dried in less than 40 but more than 24 hr. Both dried to practically clear films without any tendency to streak or run together in drops. No drying time could be obtained on lumbang oil, by repeated trials on clear and ground glass, even when the plates were placed in a practically horizontal position, due to the failure of the oil to "wet" the glass. Heating the oil to 250° C. and holding it at this temperature for ten minutes changed the color to pure light amber but did not overcome its tendency to run off the glass.

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[1] 1916 Book of A.S.T.M. Standards, p. 497.

When the oils were mixed with 5 per cent, by volume, of a liquid resinate-linoleate drier containing 2.58 per cent of lead oxide and 0.64 per cent of manganese oxide, the time of drying of the films on inclined glass plates was as follows:

Lumbang oil	6½ hr.
Perilla oil	4 "
Raw linseed oil, No. 1	5 "

All the films were practically clear and uniform. That obtained with the mixture of lumbang oil and drier was only very slightly streaked and no difficulty was experienced in securing a continuous film, in contrast to the behavior of the oil to which no drier had been added.

Perilla-Oil Varnish Test.—To test the durability of perilla oil when used in making varnishes, exposure tests were made on two varnishes made on the same formula, except that one had all the linseed oil replaced by perilla oil. These varnishes were made by a commercial varnish manufacturer and are the same samples reported on by other members of the committee. Panels were prepared, 6 by 18 in. in size, with three coats of varnish, and exposed facing south at an angle of 45 deg. to the vertical. After six weeks the panels of linseed-oil varnish began to check and alligator; after thirteen weeks, the films were almost completely disintegrated with considerable portions of the bare wood exposed. The panels of perilla-oil varnish began to show very slight checking after ten weeks; after eighteen weeks the films showed decided checking and alligatoring but were still firmly adherent and retained their gloss.

APPENDIX II.

PRELIMINARY REPORT MADE IN COMPLIANCE WITH THE DEPARTMENT OF STATE'S INSTRUCTION CONCERNING THE SOURCES OF LUMBANG AND PERILLA OILS.[1]

Lumbang Oil.—A tree known as *Aleurites triloba* is said to grow commonly in the south of China. This tree is closely allied to, or identical with, the *Aleurites moluccana* or candlenut tree, from the fruit of which lumbang oil is obtained, according to the circular enclosed with the Department's instruction. The *Aleurites triloba* bears an acorn-like fruit, called by the Chinese "stone chestnuts." A fixed oil is expressed from the kernels, which is reported to be superior to linseed oil as an economic substance. Its medicinal action is similar to that of castor oil, but it does not cause nausea or pain, and is free from any unpleasant smell or taste. Neither the fruits nor the oil appear in the Customs Reports.

Perilla Oil.—According to the circular enclosed with the Department's instruction, this oil is obtained from the seeds of *Perilla nankinensis*. A plant known as *Perilla ocimoides*, which may be identical with *Perilla nankinensis*, is referred to in Chinese *materia medica*. Its seeds grow in capsules and are about as large as mustard seeds. An oil is expressed from them which is called su-tzu-yu and is used medicinally. No reference can be found to its use economically nor can its name be found in any Customs Reports. In 1913, 4670 lb. of the seeds were exported to the United States from Dalny (Dairen).

Export Duties.—The lumbang nut is not considered to be a chestnut, but might be so classified by the Chinese Maritime Customs, in which case the duty would be 10 Haikuan tael cents per picul of 133.3 lb., amounting at present exchange to between 6 and 7 cents per 100 lb. If not so classified, an *ad valorem* duty of 5.25 per cent would be charged, which includes conservancy and wharfage dues. Perilla seeds would pay the same *ad valorem* duty.

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[1] From Consul-General Thomas Sammons, Shanghai, China.

The export duty on lumbang and perilla oils would be 30 tael cents per picul, or about 20 cents per 100 lb.

Extraction of Oil in China.—From such investigation and inquiries as have been made, it is believed that neither the lumbang tree nor the perilla plant are to be found in this Consular district, and the extent of their growth in other parts of China has not as yet been ascertained. Should it develop that sufficient quantities are obtainable to warrant exportation to America, the advisability should be considered of shipping the expressed oil rather than the nuts and seeds. The extraction of oil from beans, seeds, nuts, etc., has long been a most important industry in China. There are from 35 to 50 oil mills in various parts of the country, well equipped for the work. In 1915, more than 120,000 long tons of extracted oils of various kinds were exported from China. In view of the experience gained by these mills and of the cheapness of labor, it is thought that the oil can be more economically extracted here than in America, and the saving in freight should also be considered. Moreover, there are established markets here for the press cake remaining after the extraction of the oil.

Supplemental Report to be Submitted.—This preliminary report covers such information on the subject as is obtainable locally. As it is believed that the instruction contemplates a report for all of China, this Consulate General has requested the assistance of other consulates in its preparation. Such further information as may be obtained from them will be promptly forwarded.

REPORT OF SUB-COMMITTEE V ON LINSEED OIL.

The work undertaken by Sub-Committee V was to develop a test for the determination of the amount of so-called "foots" or precipitable matter in raw linseed oil. Each analyst was asked to apply the method to available samples of raw linseed oil known by him to be pure. No attempt was made to secure results by different analysts employing a given method on identical samples. That will follow in subsequent work, and this report will therefore consist of the individual statements of each analyst.

The sub-committee feels that the results herein contained, although not sufficient to enable it to formulate explicit directions for making the determination of the percentage of precipitable matter in linseed oil, do warrant further study. The program for the ensuing year will include effort aimed toward this end.

The sub-committee is not unmindful of the fact that it was charged with the responsibility of investigating the accuracy of the statements made by Messrs. Ware and Christman in a paper entitled "Errors in the Determination of Acid Values of Boiled Oils and Varnishes." Some work has been done but not enough to warrant the making of any definite report now.

The foots test as suggested by P. H. Walker, and later modified by F. A. Wertz, is as follows:

> "Prepare a solution of calcium chloride saturated at room temperature. To this add 10 per cent by volume of concentrated hydrochloric acid. Mix thoroughly 25 cc. each of oil and acetone and 10 cc. of the acid calcium chloride and pour into a graduated tube to settle. All should be at room temperature."

The analysts participating in the test were asked to vary those things which might, in their opinion, affect the result, such as the purity of the acetone, the temperature at which the operation should be carried out, the time of settling, and the time of mixing. The several reports are appended hereto.

Respectfully submitted on behalf of the sub-committee,

GLENN H. PICKARD,
Chairman.

APPENDIX.

REPORTS OF ANALYSTS.

Report of G. W. Thompson and C. B. Mills.

The first tests were made on very old oils from different sources. These samples had been standing for from three to six years and it was felt that practically all mucilaginous matter had separated and settled. With samples Nos. 1 to 5, inclusive, the determination was first made on the perfectly clear oil without disturbing the small layer of foots at the bottom of the bottle. The sample then was thoroughly shaken and the test repeated. The following results were obtained:

Sample No.	Kind of Oil.	Remarks.	Foots in Clear Oil, per cent.	Foots in Shaken Oil, per cent.	Ash in Clear Oil, per cent.	Ash in Shaken Oil, per cent.
1	American raw.......	Bottled Jan. 4, 1912......	Trace	1.0	.....	0.201
2	Canadian raw.......	Bottled Sept. 14, 1914....	Trace	0.8	.....	0.189
3	Calcutta raw........	Bottled Aug. 25, 1911....	Trace	0.4	.....	0.120
4	Bombay raw........	Bottled Oct. 23, 1911.....	Trace	0.4	.....	0.118
5	La Plata raw........	Bottled June 1, 1916.....	0.6	1.6	.....	0.134
6	American raw.......	1 week old..............	0.6	...	0.196	.....
7	American raw.......	2 weeks old.............	0.5	...	0.197	.....
8	American raw.......	3 weeks old.............	0.4	...	0.197	.....
9	American raw.......	4 weeks old.............	0.4	...	0.196	.....
10	American raw.......	Single filtered...........	1.2	...	0.205	.....
11	American refined.....	....	Trace	...	0.043	.....
12	La Plata............	Appeared quite turbid Dec. 23, 1916..........	1.60[a] 1.40[b]	...	0.133	.....
13	....	Appeared very bad Mar. 15, 1916...............	7.6[a] 5.2[b] 5.0[c]	...	0.159	.....
14	....	Very bad Jan. 9, 1917....	7.2[a] 5.2[b] 4.8[c]	...	0.149	.....

[a] Elapsed time, 16 hr.
[b] Elapsed time, 48 hr.
[c] Elapsed time, 72 hr.

We believe that the results given will cover all the work we have done, for although this method has been applied to a considerable number of samples, these results were all within the range of the values given, and show no differences therefrom.

It seems that where the foots content runs high, it might be difficult to obtain concordant results in less than 72 hr. It is quite possible, however, that different analysts would be able to agree with reasonable accuracy, providing conditions are adhered to closely. Insufficient mixing is certain to affect the results; time and temperature are also important factors.

REPORT OF E. W. MARTIN.

KIND OF OIL.	KIND AND AMOUNT OF FOOTS.	
Fresh common raw	Grayish brown,	0.8 per cent
Select raw	Grayish brown,	0.8 "
Chilled and settled raw, free from foots	Grayish brown,	0.4 "
Chilled and settled raw, excessive foots	Voluminous grayish,	12.2 "
Chilled and settled raw, excessive foots, melted back	Voluminous,	3.6 "
Refined linseed oil	Gray,	0.2 "
Special raw	White,	0.4 "
Settled raw plus emulsion	Grayish brown,	0.5 "

This test is a great improvement over the Holley test and has much to be recommended. The results, however, are not quantitative, since in the larger amount of precipitate of foots we find more calcium-chloride solution occluded as bubbles with the foots. Thus we get exaggerated results. The test is also more effective on a chilled oil than on a fresh oil. It is at best a quantitative guessing test.

REPORT OF GLENN H. PICKARD.

The test was first tried without the use of the calcium-chloride solution. Precipitates were obtained which distinguished differences in the quality of oils but which were of but slight quantitative value because of the variation in density of the precipitate. Some were compact and consequently occupied small space, while others were fluffy and voluminous. The use of the calcium-chloride solution rendered the compactness of the precipitate more uniform.

Different qualities of acetone seemed to make no appreciable variations in the volume of the precipitates from the same oils. Mercks U. S. P. was used in the tests reported.

The oil, acetone and calcium-chloride solution were all at room temperature, which was maintained close to 70° F. when mixed. No record of the time of agitation was recorded.

The time allowed was 24 hr. When calcium chloride was first used it was only slightly acidified. Twenty-four hours were required with this solution. When that containing 10 per cent of hydrochloric acid was employed the settling was much more rapid.

In the following are given the results obtained by applying this test to shipments of raw linseed oils made by several crushers of flaxseed and, therefore, representative of the quality of the linseed oil of our commerce this year. The other analytical constants are included as of interest in connection with the percentage of foots.

ANALYTICAL CONSTANTS OF RAW LINSEED OIL.

NORTH AMERICAN.

Specific Gravity at $\frac{15^\circ.5}{15^\circ.5}$ C.	Iodine Number.	Acid Number.	Foots, per cent.
0.9345	186.9	2.0	3.2
0.9358	189.8	1.2	0.4
0.9342	187.9	1.4	0.4
0.9348	182.0	2.3	1.6
0.9345	186.9	0.8	2.0
0.9348	189.2	1.0	0.8
0.9338	187.5	2.2	0.4
0.9349	186.1	0.8	2.0
0.9340	185.7	2.0	4.0
0.9341	187.2	2.2	1.5
0.9347	187.2	2.0	1.2
0.9347	184.4	2.3	2.0
0.9346	184.8	2.3	1.2
0.9344	182.4	3.2	2.0
0.9343	183.4	4.0	2.8
0.9343	183.8	3.1	3.6
0.9346	184.5	1.8	1.0
0.9347	183.3	2.4	2.5
0.9346	185.2	2.4	1.6
0.9344	184.3	2.9	2.0
0.9342	184.4	2.1	1.6
0.9342	186.4	1.7	0.8
0.9343	185.3	0.9	0.4
0.9341	188.3	1.9	3.6
0.9340	185.7	1.7	1.6
0.9345	186.8	0.5	0.8
0.9346	186.6	1.1	1.6
SOUTH AMERICAN.			
0.9326	173.2	4.0	2.8
0.9326	176.1	2.6	3.2
0.9323	176.0	4.2	2.8
0.9327	175.6	4.0	3.6
0.9326	174.9	4.0	4.0
0.9318	175.3	2.1	2.4
0.9327	175.1	3.4	2.8
0.9322	176.5	2.1	4.0

REPORT OF F. A. WERTZ.

In attempts to cause the rapid settling of foots in linseed oils, the oils were diluted with varying proportions of the more common solvents such as gasoline, acetone, ether, chloroform, benzol, and carbon bisulfide. Of these, acetone seemed to be the most suitable, and it was found that the presence of mineral acid was desirable. A method which finally appeared to be satisfactory for the quantitative determination of the amount of foots in samples of raw linseed oil is as follows:

Twenty-five cubic centimeters of acetone, 25 cc. of the linseed oil, and 5 cc. of a saturated calcium-chloride solution, acidified with hydrochloric acid, are poured into a graduated, small-bore, glass tube of suitable capacity. The constituents should all be at a temperature of approximately 21° C. (70° F.). After stoppering and mixing thoroughly the tube should be placed in a tall cylinder filled with water at 21° C. (70° F.), and allowed to stand over night. The calcium-chloride solution will form a layer in the bottom of the tube, the acetone-linseed oil mixture will form a layer in the upper part of the tube, and the foots will form a sharply defined layer between the two. The volume of the foots is read from the graduations on the tube.

The acetone may be of any good commercial grade. Experiments with various grades of acetone containing added quantities of wood alcohol and water indicate that these constituents, when present in reasonably small quantities, do not affect the volume of foots to any appreciable extent; but when a large quantity of either of these constituents is present, the acetone-linseed oil mixture will separate into two layers. If this condition does not occur the acetone is probably suitable for use.

The calcium-chloride solution is made by saturating water containing about 10 per cent by volume of concentrated hydrochloric acid with calcium chloride. On dissolving the calcium chloride considerable heat is evolved, and on cooling the solution to room temperature, crystallin calcium chloride should be deposited. The clear, supernatant liquid should have a specific gravity of approximately 1.357 at 25° C. and should be approximately two-thirds normal in acidity (HCl).

The graduated glass tube may conveniently be a 50-cc. eudiometer tube, or a discarded 50-cc. burette with the lower end sealed. The dimensions of such a tube are approximately 1 cm. in inside diameter, and 60 cm. in length. The graduations should start not more than 5 cc. from the sealed end of the tube, so that the layer of foots will come in the graduated portion, and the total capacity of the tube should be at least 55 cc. The great difference in the specific gravity of some of the constituents makes thorough mixing very easy by merely turning the tube end-over-end several times.

The temperature of mixing seems to have a slight effect on the volume of the foots layer obtained from a given sample of oil. For this reason, the constituents of the mixture should be within a few degrees of the arbitrarily chosen temperature of 21° C. (70° F.); and immediately after mixing, the tube should be placed in as nearly a vertical position as possible, in a water bath at 21° C. (70° F.). A tall, 2-liter measuring cylinder makes a suitable bath. With a calcium-chloride solution of the required acidity, the coagulation and precipitation of the foots takes place so rapidly that it is practically complete before any temperature changes of the laboratory could affect the volume of foots. Preliminary comparative readings on the quantity of foots may be made in one or two hours, but final readings should not be made before the tubes have been allowed to stand over night.

The method of testing as described has been used on 50 samples of oil that have been submitted to this laboratory, with the following results:

Eight oils were exceptionally clear and showed no foots whatever, or at least less than a measurable quantity of foots; 14 oils were clear and showed more than traces, but not more than 0.1 cc. of foots; 14 oils were only very faintly turbid or contained only traces of sediment, and showed more than 0.1 cc., but less than 0.2 cc. of foots; 8 oils were of medium turbidity or contained small amounts of sediment, and showed more than 0.2 cc., but less than 0.5 cc. of foots; and 6 oils were excessively turbid or contained excessive amounts of sediment and showed more than 0.5 cc. (0.6 to 4.2 cc.) of foots.

From the results obtained on these oils, it is believed that any oil showing a volume of foots, as determined by this test, of as much as 0.5 cc. would not be considered to be of suitable quality for most commercial purposes.

The effect of the presence of moisture in a sample was determined by testing perfectly clear oils to which water had been added. On shaking these oils, and allowing them to stand, considerable quantities of a light yellow precipitate or emulsion deposited. However, when these oils containing water were subjected to the test, a layer of foots did not separate. This indicates that the test does not measure as foots, such turbidity or sediment in an oil which is due to the presence of moisture.

REPORT OF M. Y. SEATON.

COMPARISON OF C. D. HOLLEY'S METHOD FOR THE DETERMINATION OF FOOTS IN LINSEED OIL WITH THE METHOD SUGGESTED BY P. H. WALKER.

Holley's method consists of adding petroleum naphtha of definite specific gravity to the oil under test, adding a definite amount of phosphoric acid, shaking for a specified time, and allowing to stand at a specified temperature for a considerable length of time, and reading the percentage of foots.

The method suggested by Walker consists of mixing 25 cc. of acetone with 25 cc. of the oil; placing this mixture in a burette or suitable measuring tube; adding to it 10 cc. of saturated calcium-chloride solution (acidified with 10 cc. of concentrated hydrochloric acid to the 100 cc. of solution); and allowing the foots to settle. In this case they will appear at the boundary between the calcium-chloride solution and the linseed oil.

No attempt was made to vary the experimental conditions in Holley's method. It was used exactly as specified by Holley in his paper[1] before the Society in 1916. Excellent checks as regards the percentage of foots can be obtained by this method, and although there is little doubt but that variation in experimental conditions will vary the amount of foots observed, apparently these conditions can be so regulated as to avoid this possibility of error.

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[1] "The Acceptability of Linseed Oil," *Proceedings*, Am. Soc. Test. Mats., **Vol. XVI, Part** II, p. 239 (1916).

Walker's method is in general found to give excellent results provided experimental conditions are the same, but the observed percentage of foots depends entirely on the length of time the oil-acetone mixture is shaken with the calcium chloride. In carrying on the method, either Mohr's burettes sealed at the bottom or standard phenol tubes were used. These latter are tubes about burette size graduated to 100 cc., and contain at the top an enlargement or bulb giving a total capacity of 100 cc. The following are the results obtained on two samples of oil:

Sample No.	Remarks.	Holley's Method.		Walker's Method. (phenol tubes).	
		Time of Settling, hr.	Foots, per cent.	Time of Settling, hr.	Foots, per cent.
1	....	5	2.0	..	...
	....	24	1.0	..	...
	Shaken 1 min...............	..	...	4	1.2
		..	...	24	1.2
	Shaken 5 min...............	..	...	2	3.2
		..	...	24	2.8
		..	...	48	2.4
	Mixture placed in burette and $CaCl_2$ solution slowly poured through it.................	..	...	24	1.6
2	....	24	2.0	..	...
	Shaken 1 min..............	..	...	4	2.4
		..	...	24	2.4
		..	...	2	2.4^a
		..	...	12	2.4^a
		..	...	2	3.2^a
		..	...	12	3.2^a
		..	...	1	2.4^a
		..	...	18	1.6^a
		..	...	1	2.2^a
		..	...	18	1.6^a
		..	...	1	2.4^a
		..	...	18	1.6^a
	Mixture placed in burette, and $CaCl_2$ solution slowly poured through it.................	..	...	2	1.6^a
				18	1.6^a

^{a} Burettes.

Further work, varying experimental conditions, is under way.

REPORT OF E. J. PROBECK.

It was found that by shaking 100-cc. burettes for 1 min., using Walker's method, concordant results could be obtained, and they checked very well.

Sample No. 3 of linseed oil by Walker's method gave the following results:

	FOOTS, PER CENT.
Shaking 1 minute; after 1 hr	2.4
	2.2
	2.4
Shaking 1 minute; after 18 hr	1.6
	1.6
	1.6
Shaking 5 minutes; after 1 hr	3.6
	3.6
	3.2
Shaking 5 minutes; after 24 hr	2.8
	2.8
	2.8

REPORT OF SUB-COMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS.

Sub-Committee VIII reports as follows:

1. No criticism having been received of the Tentative Methods for Routine Analysis of White Pigments as published in the Proceedings,[1] it is recommended that these methods be submitted to letter ballot for adoption as standard.

2. It is recommended that the methods for Analysis of Red Lead published in the Proceedings,[2] be published among the Tentative Standards of the Society with a view of being adopted as standard a year hence.

3. Methods compiled from the literature are submitted herewith as proposed Tentative Methods for Routine Analysis of Yellow, Orange, Red, and Brown Pigments containing Iron and Manganese.[3]

Respectfully submitted on behalf of the sub-committee,

F. W. SMITHER,
Chairman.

EDITORIAL NOTE

See Addendum to Report of Committee D-1, page 460.

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[1] Vol. XVI, Part I, p. 536 (1916).

[2] Vol. XIV, Part I, p. 281 (1914). See this volume, pp. 796–801.—ED.

[3] See pp. 802–809.—ED.

REPORT OF SUB-COMMITTEE IX ON VARNISH.

At a meeting held April 25, 1916, the sub-committee accepted with much regret the resignation of Mr. S. S. Voorhees as chairman, a post he felt it necessary to relinquish on account of pressing duties in other directions.

The committee then reorganized, electing Mr. Allen Rogers as chairman and Mr. F. P. Ingalls as secretary. The following names finally were chosen to constitute the membership:

Bragg, C. T.;
Burleigh, W. F.;
Cole, E. J.;
Dewar, J.;
Heckel, G. B.;
Holton, E. C.;
Ingalls, F. P., *Secretary;*
Lindsay, R. W.;
Macnichol, C.
McDonnell, M. E.;
McIlhiney, P. C.;
Nemzek, L. P.;
Rogers, Allen, *Chairman;*
Sabin, A. H.;
Sanderson, J. M.;
Seaton, M. Y.;
Wertz, F. A.;
Young, J. B.,

In the discussion which followed, the difficulties in the way of determining composition by direct analytical methods were considered at some length; and also the indeterminate relation between compositions and actual service value. General opinion seemed to point to the empirical tests more or less commonly used in daily practice, as promising a greater degree of success in estimating the adaptability of a varnish to given requirements, and its probable value in service.

In accordance with these ideas a letter was sent to each member of the sub-committee, requesting that he make out a list of such tests as he was in the habit of using, or which he thought might be developed into useful tests, and forward them to the chairman at as early a date as possible.

At a meeting of the sub-committee held June 27, 1916, the tests submitted were given careful consideration and as a result of the discussion a line of procedure was adopted which it was hoped would prove a basis for more extended study of the subject.

The varnishes to be tested were to be prepared by Mr. M. Y. Seaton of the Arco Co. and were to consist of three types, namely, Kauri Gum, Manila Gum and Chinese Wood Oil. The method of manufacturing and amount of materials used were to be known to the sub-committee.

The tests proposed and tentatively adopted were the following:

1. *Volatile Thinner.*—(*a*) Steam distillation; (*b*) Heating in a current of neutral gas.

2. *Specific Gravity.*—(*a*) Specific-gravity bottle; (*b*) Plummet method. (Density reported at 25° C. compared to water at 4° C.).

3. *Alkali Test.*—Place black enamel and varnish plates (2 coats) in closed vessel in the bottom of which is another vessel containing 30 cc. of 20° Baumé ammonia and 25 g. of lump lime. Expose 24 hours and note effect.

4. *Viscosity.*—The method to be used left open for further consideration.

5. *Drying Test.*—Use weighed friction top can covers about 3½ in. in diameter. Weigh varnish by difference carrying varnish to cover by means of brush and spread to proper thickness.

6. *Loss on Evaporation.*—Weigh cover and varnish after two hours and again each day for one week.

7. *Cold-Water Resisting Test.*—Black enamel plates and maple panels to be given two coats, dried one week and then half submerged in cold water for one week. Note time to turn white or other conditions.

8. *Hot-Water Test.*—Apply two coats of varnish to mahogany panels, dry for one week. Cover panels with piece of 6-oz. duck wet with hot water, and then place on top of duck a 1-qt. friction top can filled with boiling water. Allow to stand until cold. Note effect.

9. *Soap Test.*—Use black enamel plates having two coats of varnish half immersed in water containing 1 oz. of Ivory Soap to 1 gal. of water at 180° F. Let stand one-half hour and note results.

10. *Weather Test.*—Apply two coats of varnish to maple panels and expose to weather making observations at monthly periods.

On August 4, 1916, Mr. M. Y. Seaton shipped to the chairman two 5-gal. cans of varnish of the Kauri-gum and Chinese-wood-oil types, no Manila gum type being available at that time.

The sample marked V-410 was the Kauri-gum varnish and contained 100 lb. of No. 1 Kauri-gum to 28 gal. of linseed oil, thinned with 32 gal. of turpentine. The driers used consisted of small amounts of cobalt and manganese. The temperature was run to about 600° F. and held there for one hour.

The sample marked V-415 was the Chinese-wood-oil varnish made with 50 gal. of oil and 150 lb. of special Ester gum. Manganese and lead driers were used and the product thinned with 10 gal. of turpentine and 70 gal. of turpentine substitute. The temperature was run to 550° F. and held for about 2½ hours.

On August 18, 1916, Mr. L. V. Pulsifer, through the courtesy of Valentine and Co., furnished the sub-committee with 200 each of maple, mahogany and black enamel panels to be used in the tests. Both the maple and mahogany panels were filled on one side with a good-grade wood filler.

Some delay was caused in securing proper containers, but on October 30 samples of varnish and panels were sent to all the members of the sub-committee who had signified their willingness to carry out the tests. The results were to be in the hands of the chairman on or about April 1, 1917.

The reports of the members participating in the tests are appended hereto.

On April 12, 1917, the sub-committee met and took under consideration the results of these tests. After some discussion on the various phases of the work it was decided to recommend the following:

1. That the Volatile Thinner be determined by direct evaporation for 3 hr. at a temperature of 110 to 115° F.; steam distillation to be employed only when a knowledge of the volatile thinner is desired.

2. Both the Specific-Gravity Bottle and Plummet Method were approved for use in determining specific gravity.

3. The Alkali Test should be retained, but with the understanding that it is a special test and limited in its application.

4. The matter of determining the best method to use for

Viscosity determination is to be left for future consideration. The chairman is to secure data on obtaining standard tubes.

5. The Drying Test on can covers was considered to be unreliable and unsatisfactory.

6. On account of the wide variation in Drying Observations it was decided to obtain sufficient data from the members to arrive at definitions which would describe the condition of the film at various degrees of drying; for example, dust-proof, tacky, cheesy, skin or surface dry, solid, thoroughly dry.

7. The Cold-Water Test should be retained, but in addition a series of tests should be made in which the panels should be alternately wet and dried. This test should be applied only to varnishes intended for this kind of exposure.

8. It was recommended that the Hot-Water Test be called Impression Test (Print Test). It was also recommended that two additional tests be made, one in which the canvas should be dry, and another in which the canvas should be dry and a cold weight applied for a longer period.

9. The Soap Test should be retained, but with the understanding that it is a special test and limited in its application

10. The Weather Test should be retained, but should be applied only to varnishes intended for outside application. All exposure should be made at an angle of 45 deg. to southern exposure.

It was further recommended that future tests be confined to definite classes of varnishes; also, it was suggested that the hardness of varnish films be given some consideration.

Respectfully submitted on behalf of the sub-committee,

ALLEN ROGERS,
Chairman.

APPENDIX.

REPORTS OF ANALYSTS.

The following compilations consist of excerpts from the reports from the various members who collaborated in the tests:

1. VOLATILE THINNER.

(*a*) *Steam Distillation.*—The method employed for the determination of volatile thinner was the one in common use, which consists of heating 50 g. of the varnish in a distilling flask and passing a rapid current of steam through it, continuing until no more drops of oil were observed in the condenser, and reporting the result as percentage of the varnish. The results of these tests are given in Table I.

TABLE I.—RESULTS OF TESTS FOR VOLATILE THINNER, STEAM DISTILLATION.

Operator.	Volatile Thinner, per cent.	
	Varnish No. 410.	Varnish No. 415.
Wertz	40.0	45.8
	39.9	45.9
Average	40.0[a]	45.9[a]
	41.2	47.6
	41.6	48.0
Average	41.4[b]	47.8[b]
Holton	37.43	42.40
Sohl		
Corrected for Solubility	39.60	44.23
E. Ingalls	37.80	43.10
Corrected for Solubility	39.80	44.30
Bragg	40.34	44.85
	40.16	44.97
	40.25	44.91
Seaton	39.0	44.6
	39.9	44.2
	39.5	44.4

[a] Uncorrected.

[b] Corrected for solubility of the volatile portion in water, assuming 0.3 g. of volatile vehicle dissolved in each 100 cc. of condensed water.

TABLE I.—*Continued.*

Operator.	Volatile Thinner, per cent.	
	Varnish No. 410.	Varnish No. 415.
Mills	40.79	44.69
Sabin	40.30	45.09
Thompson	40.55	44.89
F P. Ingalls	38.67	43.58
	39.01	43.80
	38.89	43.69
Nemzek	40.0	47.1
	41.0	45.4
Lindsay	57.33	66.76
Burleigh	37.90	44.60
Corrected for Solubility	40.40	47.10
Cole	43.1	45.5

Remarks by F. A. Wertz.—The simplest and most convenient method for determining the percentage of volatile thinner is by weighing by difference from a stoppered vial about 1.5 g. of the varnish on to a tared friction top can cover, about 11 cm. (3½ in.) in diameter, and noting the loss in weight after heating from three to five hours at 110 to 115° C. in an air bath. Results by this method are apparently accurate, and can be duplicated without difficulty.

The steam distillation was made on a 100-g. sample of varnish with the still heated in an oil bath at 115 to 130° C., and steam passed in for 1¼ to 1½ hrs. The volatile thinner was then separated from the water in the distillate and weighed. This method seems to be the most cumbersome, and gives the most variable results. It is not believed that a correction of 0.3 g. of volatile matter for each 100 cc. of condensed water is justifiable, nor that it gives figures more nearly correct.

Remarks by C. T. Bragg.—The percentage of volatile thinner was determined by distilling a 50-g. sample of varnish with steam. The distillate was caught in a burette and the water drawn off as it became necessary. After standing over night in the corked burette, the cubic centimeters of thinner present were read. The specific gravity of the thinner was then determined at 15.°5/15.°5 C., since the varnish was weighed out at approximately this temperature. The amount of thinner was calculated from knowledge of the cubic centimeters of thinner and the specific gravity.

The specific gravity of the volatile thinner at 15.°5/15.°5 C. for varnish No. 410 was 0.8622; for varnish No. 415, 0.7926.

Remarks by M. Y. Seaton.—Although the method worked fairly well on the two varnishes in question, it has been frequently observed in this laboratory that with the short-oil varnishes, such as rubbing varnishes, the varnish base becomes very thick and viscous before distillation of the volatile matter is complete. Accordingly, the method is not accurate for such materials.

Remarks by L. P. Nemzek.—The volatile was also determined by "evaporation" at 105° C., showing the following results: Varnish No. 410, 40.4 per cent; varnish No. 415, 46.0 per cent.

The "volatile by evaporation" was determined in accordance with the following method:

Two culture dishes are selected about 10 mm. in depth, one of which is about 75 mm. in diameter, the other about 80 mm. in diameter. The larger, when inverted over the smaller, will fit closely and prevent tendency toward evaporation. These two dishes are then weighed together, after which a convenient quantity of the liquid to be tested is placed in the smaller—usually just enough to cover the bottom of the dish with a layer of material 3 to 5 mm. in thickness. The larger dish is then quickly inverted over the smaller, and both dishes and volatile are again weighed. The larger dish is then removed and the smaller dish is placed within the larger, after which they are subjected to heat from three to five hours, or until weight is constant.

$$\frac{(\text{Weight of dishes}+\text{material})-(\text{Weight of dishes}+\text{residue})}{(\text{Weight of dishes}+\text{material})-(\text{Weight of dish})}\times 100=\text{per cent of volume by weight.}$$

(*b*) *Heating in a Current of Neutral Gas* (CO_2).—The method followed consisted essentially of placing a small sample of the varnish in an Erlenmeyer flask provided with inlet and outlet tubes, and heating it in the oven, during which time a rapid stream of dry inert gas was passed through the container. The results of these tests are given in Table II.

Remarks by C. T. Bragg.—This determination proved unsatisfactory until a small sample of from 2 to 3 g. was used and the sample smeared well over the inside of an Erlenmeyer flask before heating. It was found that by maintaining a temperature of 120° C. for two hours, results which represented the maximum loss which was calculated as thinner were obtained. It was also found that the accuracy of this experiment was increased, rather than to the contrary, in the use of the small sample, for a larger sample required longer heating and a large amount of the viscous residue occluded some of the thinner, the apparent loss then being less than the true loss.

Remarks by M. Y. Seaton.—It will be noted that the results are somewhat higher than the results obtained in steam distillation, because of the difficulty in removing all of the volatile in the steam distillation. An apparent decrease in the percentage of volatile is shown at the end. This can be ascribed to oxidation of the varnish film by oxygen, contained as impurity in the carbon dioxide. When the carbon dioxide is purified by passage through a tube of hot copper turnings, this trouble does not occur.

When an attempt is made to replace carbon dioxide by hydrogen, it is found that the volatile is much slower in coming off, requiring from three to four hours for attainment of constant weight. Therefore, the method using carbon dioxide is recommended.

Remarks by F. P. Ingalls.—The varnish was weighed out in a weighing pipette, the amount taken weighed by difference and introduced into a 300-cc. Erlenmeyer flask with a flat bottom. This was connected up with a CO_2 generator and a stream of gas, dried by passing through H_2SO_4, was run through the flask for two hours while the flask was kept on an actively boiling water bath. The flask was rapidly cooled, inverted to replace the CO_2 by air, and immediately weighed.

TABLE II.—RESULTS OF TESTS FOR VOLATILE THINNER, HEATING IN CO^2.

Operator.	Temperature of Oven, deg. Cent.	Time of Heating, hr.	Volatile Thinner, per cent.	
			Varnish No. 410.	Varnish No. 415.
Wertz.........	110–115	5	40.6	46.5
	110–115	5	40.8	46.4
	110–115	5	40.7	46.5
Holton.......... Sohl............	110–115	5	41.25	44.62
Bragg.........	110–115	5	40.91	46.97
	110–115	5	40.84	46.80
	110–115	5	40.88	46.89
Seaton........	150	2	35.1	45.2
	150	2	36.2	46.0
	150	4	38.3	46.7[a]
	150	4	37.5	46.4
	180	6	41.0	....
	180	1	40.6	46.9
	180	1½	40.8	46.0
	180	1½	41.2	46.9
	180	1½	41.2	46.8
	180	2½	41.05	46.2[b]
	180	2½	41.00	45.9
Mills..........	120	3	40.83	46.36
	120	3	40.68	46.41
	120	3	40.76	46.39
F. P. Ingalls...	95	2	40.05	45.33
	95	2	39.60	45.58
	95	2	39.82	45.35
Lindsay...............................			56.95	55.48
Burleigh[c]............................			40.7	47.0
			40.1	46.7
			40.4	46.9

[a] Heated 3 hr.
[b] Heated 4 hr.
[c] Illuminating gas used.

2. SPECIFIC GRAVITY.

The specific gravity was determined by both the specific gravity bottle and plummet methods. The results are given in Table III.

Remarks by L. P. Nemzek.—The specific gravities of the two varnishes were determined by pyknometer at 15.°6/15.°6 C. and computed to density at 15.°6/4.°0 C., using the coefficient given by Van Nostrand,[1] 0.99908.

3. ALKALI TEST.

Report of F. A. Wertz.—Both films darkened.

Report of E. C. Holton.—Both films darkened, varnish No. 410 a bit more than No. 415.

Report of C. T. Bragg.—No change.

Report of M. Y. Seaton.—No change after 24 hr.; after one week both films became darker.

TABLE III.—DETERMINATION OF SPECIFIC GRAVITY.

Operator.	Specific Gravity.			
	Bottle Method.		Plummet Method.	
	Varnish No. 410.	Varnish No. 415.	Varnish No. 410.	Varnish No. 415.
Wertz	0.9254	0.8979	0.9262	0.8984
Holton	0.9301	0.9004	0.9294	0.8994
Ingalls	0.9320	0.9035	......	......
Bragg	0.9264	0.8985	......	......
Seaton	0.9264	0.8983	0.9270	0.8990
Mills	0.9265	0.8987	......	......
F. P. Ingalls	0.9285	0.9000	......	......
Nemzek	0.9299	0.9017	0.9300	0.9020
Lindsay	0.9280	0.9010	0.9260	0.9000
Burleigh	0.9276	0.8974	......	......
	0.9261	0.8973	0.9283	0.8967
	0.9280	0.8974	......	......
E. Ingalls	......	......	0.9262	0.9012
Cole	......	......	0.9330	0.9050
	......	......	0.9350	0.9050

Report of C. B. Mills.—No change.

Report of F. P. Ingalls.—Both samples darkened.

Report of L. P. Nemzek.—No change.

Report of John Dewar.—Darkening of films noticed.

Report of R. W. Lindsay.—On black enamel plate, after test, varnish No. 410 showed a distinct green florescence. Varnish on mahogany panel was rough in places and had a very slight bloom in spots. Entire panel was also darkened very considerably.

Varnish No. 415 on black enamel plate showed a greenish gray florescence. Varnish on mahogany panel showed slight bloom in places and wood very much darkened.

Report of W. F. Burleigh.—No change was found after being subjected to ammonia fumes for 24 hr., except perhaps a slight softening. The test is not satisfactory. There was some yellowing.

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[1] "Chemical Annual," 3d issue, 1913, p. 416.

Report of E. J. Cole.—No change noted; mahogany panels, where exposed. darkened as in fuming.

4. VISCOSITY.

Tests on viscosity postponed.

5. DRYING TESTS.

Tables IV and V give the results of the drying tests.

Remarks by F. A. Wertz.—These results indicate that loss on evaporation by weighing films that have been brushed out or flowed on metal or glass, is dependent on so many variables that the method is not likely to be of any analytical or practical value. It is to be noted that in the case of the very thin films, the results given after 72 and 152 days indicate that varnish No. 410 began to lose weight other than that due to loss of volatile thinner, while varnish No. 415, after evaporation of the volatile thinner, continued to gain in weight during the whole period of test.

TABLE IV.—RESULTS OF DRYING TESTS USING FRICTION TOP CAN COVER.

Operator.	Loss on Evaporation, per cent.															
	Varnish No. 410.								Varnish No. 415.							
	Elapsed Time.								Elapsed Time.							
	2 hr.	1 day	2 days	3 days	4 days	5 days	6 days	7 days	2 hr.	1 day	2 days	3 days	4 days	5 days	6 days	7 days
Wertz	38.3	34.2	33.7	33.4	33.4	....	....	33.3	42.2	42.8	41.9	41.4	41.2	....	....	40.7
Holton	33.8	37.5	37.9	36.6	36.4	36.2	....	....	30.3	45.3	44.2	43.7	43.3	43.3	....	....
E. Ingalls	38.5	38.5	38.2	....	37.6	37.6	37.5	37.2	45.6	47.0	46.4	....	45.9	45.8	45.6	45.4
Bragg	40.7	34.8	34.0	34.0	33.9	33.2	....	33.2	45.5	43.7	42.3	42.1	42.1	41.7	....	41.3
Seaton	35.2	29.6	28.6	28.6	28.6	28.6	28.6	28.9	37.7	55.5	33.9	33.9	33.6	....	33.8	33.9
Mills	41.0	34.7	33.9	33.4	33.9	33.4	33.3	....	45.7	45.5	42.8	42.2	42.0	41.6	41.4	....
Nemzek	41.5	37.6	36.8	35.8	35.8	....	35.8	35.6	44.7	44.1	42.8	42.5	42.2	....	41.9	41.9
Lindsay	32.8	30.1	30.0	29.1	27.4	27.0	27.0	26.9	40.8	41.4	42.0	42.3	38.0	37.9	37.6	37.6
Burleigh	40.4	34.9	....	....	....	....	....	....	42.3	45.2	....	....	....	....	....	....
Cole	35.1	32.7	31.7	31.3	....	....	....	....	41.1	40.0	39.4	38.8	....	....	....	....

Remarks by M. Y. Seaton.—It is interesting to note that the loss on evaporation is by no means as great as the percentage of volatile thinners obtained by either of the methods. This is undoubtedly due to increase in weight of the film by oxygen absorption.

Remarks by F. P. Ingalls.—It was found to be impracticable to spread a definite amount of varnish with a brush, on account of the escape of volatile thinner during the operation. The method as given may be practicable with drying oils, but I do not consider it suitable for varnishes.

Remarks by W. F. Burleigh.—Accurate results can be obtained if the weighings, especially the first, are made rapidly, and if the temperature and the quantity of varnish weighed out is uniform. In two hours practically all the thinners will have evaporated. The greatest changes in the state of the film run parallel with the greatest changes in weight and the nature of the varnish determines whether the changes in weight, coincident with the changes in state, will be comparatively large or small. It is seen that the total change in weight, after the thinners have evaporated, in varnish No. 410 is about twice that of varnish No. 415. Since the volatile matter in both varnishes at some time approaches closely to that determined by analysis, it indicates that the dry in the one case is due to its greater power of adding oxygen, while in the other the dry is due to polymerization, rather than the fact that there is an over-lapping of the processes of loss of weight by evaporation and the gaining of weight by oxidation. The process in drying can readily be followed by the changes in weight. By flowing the varnish on glass rather than brushing it, a heavier film is formed and the corresponding change will be slower.

6. DRYING OBSERVATIONS.

Report of C. T. Bragg.—Varnish No. 415 dried in 18 hr., and No. 410 in 10 hr., room temperature. These varnishes were termed dry when no white streak resulted from drawing the finger across them.

TABLE V.—RESULTS OF DRYING TESTS USING GLASS PLATES.

Operator.	Loss on Evaporation, per cent.															
	Varnish No. 410.								Varnish No. 415.							
	Elapsed Time.								Elapsed Time.							
	2 hr.	1 day	2 days	3 days	4 days	5 days	6 days	7 days	2 hr.	1 day	2 days	3 days	4 days	5 days	6 days	7 days
Holton	28.9	37.8	37.4	37.3	36.9	37.4	....	....	36.2	41.3	41.0	41.0	44.8	40.3	....	....
Bragg	40.5	34.6	34.0	33.9	33.5	33.2	....	33.1	40.5	34.6	34.0	33.9	33.5	33.2	....	33.1
Mills	....	33.8	32.9	32.4	32.5	32.3	32.3	....	45.9	45.4	42.8	42.0	42.1	41.8	41.7	....
Nemzek	....	....	....	....	....	....	....	....	45.8	45.8	43.6	43.0	43.0	....	42.8	42.8
Lindsay	35.5	34.5	33.4	32.7	31.7	31.6	31.4	31.4	....	....	....	....	....	....	....	....

Report of M. Y. Seaton.—Varnish No. 410 was fairly soft and there was no tack after 24 hr.; hard and free from tack after 48 hr. Varnish No. 415 was slightly tacky and somewhat soft at end of 24 hr.; hard and free from tack after 48 hr.

Report of Allen Rogers.—Varnish No. 410 tacky at end of 8 hr.; dry at end of 24 hr. with slight soft feel; completely dry after 48 hr. Varnish No. 415, was still wet after 8 hr.; tacky after 24 hr.; dry at end of 48 hr.

Report of John Dewar.—Varnish No. 410, one coat, 24 hr. after coating, film can be moved about under pressure of finger, showing body of varnish still soft; 48 hr. after coating surface showed impression of fingers; 72 hr. after coating surface, slight tack under pressure; 96 hr. after coating, varnish appeared to be dry; 168 hr. (7 days) after first coat, still retained slight tack on strong pressure. Clogs sandpaper.

Second coat after 24 hr., tacky; 48 hr., tack under pressure; 72 hr., finger mark under pressure; 96 hr., finger mark under pressure; 120 hr., tacky under pressure. Clogs sandpaper.

Third coat after 24 hr., quite tacky; 48 hr., slightly tacky; 144 hr., still shows finger marks under pressure; 168 hr., dry and hard. Clogs sandpaper.

Varnish No. 415, one coat; 24 hr. after coating, film can be moved under pressure of finger; 48 hr., slight impression on pressure and appears to be drying through body; 72 hr., impression of finger under pressure; 96 hr., hard and dry; 168 hr. (7 days), good coating. Sandpapers freely.

Second coat after 24 hr., tacky; 48 hr., tacky under pressure; 72 hr., dry and hard; 96 hr., dry and hard; 120 hr., dry and hard. Sandpapers freely.

Third coat after 24 hr., tacky; 48 hr., tackiness disappears, finger marks under pressure; 144 hr., dry and hard; 168 hr., dry and hard. Sandpapers freely.

7. COLD-WATER RESISTING TEST.

BLACK ENAMEL PANELS.

Report of F. A. Wertz.—Varnish No. 410, after 6 hr., not affected; 24 hr., slightly dulled; 2 days, slightly more whitening; 3 days, as after 2 days; 4 days, decidedly roughened; 8 days, roughened, whitened; 15 days, as after 8 days but more so.

Varnish No. 415, after 6 hr., unaffected; 24 hr., slightly dulled and whitened; 15 days, slightly dulled and whitened.

Report of E. G. Holton.—Varnish No. 410 showed signs of turning white in 3 days; at end of week panels had turned white.

With varnish No. 415, the coating turned white after 3 days but not so much as 410.

Report of C. T. Bragg.—Varnish No. 410 showed tendency toward whiteness at end of 5 days; 7 days, opaqueness was pronounced.

Varnish No. 415 turned white at end of 5 days.

Report of M. Y. Seaton.—Varnish No. 410, after 24 hr., showed slight whitening, slight loss of glass; 3 days, slightly soft and white; 5 days, slightly soft and white; 8 days, very soft and white; 14 days, white, soft and crumbly.

Varnish No. 415, after 24 hr. was perfect; 3 days, slightly white; 5 days slightly white and soft; 8 days white but slightly soft; 14 days, white and slightly soft.

Report of C. B. Mills.—Varnish No. 410 became somewhat cloudy and entire surface appeared to be covered with very fine pimples or blisters. The films were quite soft. Easily scattered and removed without difficulty.

The film of varnish No. 415 at end of 7 days was decidedly milky, but seemed tougher than that of varnish No. 410.

Report of F. P. Ingalls.—Varnish No. 410, after 24 hr., was quite blue; 2 days, quite blue, surface extremely pinholed; 4 days, blue and pinholing regular all over plate; 5 days, same as for 4 days; 6 days, same as for 5 days; 8 days, uniformed bluish white and pinholed all over.

Varnish No. 415, after 24 hr., was not appreciably affected; 2 days, slight pinholing along side and top; 4 days, no change; 5 days, no change from 2 days; 6 days, began to show disintegration and slightly blue; 8 days, slightly blue and pinholed in spots.

Report of L. P. Nemzek.—With varnish No. 410, after 24 hr., whitening began to develop; 7 days, marked degree of whitening and heavy bloom.

Report of John Dewar.—With varnish No. 410, after 7 days, the coating was very blue in color and could be easily removed by finger nail.

MAHOGANY PANELS.

All tests show about the same as on metal plates, except the changes are not so marked. This test will be tabulated later.

Report of F. A. Wertz.—Varnish No. 410, after 6 hr., was unaffected; 24 hr., practically unaffected except that grain was raised near end of panel; 2 days, as after 24 hr., except somewhat dulled; 3 days, whitening barely noticeable; 4 days, whitened especially around edges of panel; 8 days, as after 4 days; 15 days, whitened.

Varnish No. 415, after 6 hr., was unaffected; 24 hr., unaffected except that grain is raised near end of panel; 2 days, as after 24 hr., except slightly dulled; 3 days, as after 2 days; 4 days, very slightly whitened, especially around edges of panel; 8 days, as after 4 days, not whitened as much as varnish No. 410; 15 days, as after 8 days, not whitened as much as varnish No. 410.

Report of E. C. Holton.—At the end of a week all panels had turned white, but the mahogany panels did not show this whitening as much as the black enamel plates.

Report of C. T. Bragg.—The mahogany panels did not show any of the opaqueness which was apparent on the black enamel plates; neither was the gloss in any way affected. In fact, the mahogany panels were in every respect as good at the end of the test as at the beginning.

Report of M. Y. Seaton.—Varnish No. 410, after 24 hr., was perfect; 3 days, perfect; 5 days, perfect; 8 days, slightly white but hard; 14 days, loss of gloss and slightly soft. Film in good condition.

Varnish No. 415 was in perfect condition until the end of 14 days, when one or two spots near edge of panel developed.

Report of C. B. Mills.—The mahogany panels showed practically no change; the luster and general appearance was about the same as the exposed portion and the film was quite as hard and tough.

Report of F. P. Ingalls.—No change in either panel after 5 days. After 6 days no change except that varnish No. 410 was slightly better than No. 415. After 8 days varnish No. 415 lost some of its gloss, but was good in every other way except where water worked in under the grain. Varnish No. 410 was perfect. This test is obviously of considerable value and while there seems to be a difference in degree between the results on the black enamel plates and those on the panels, the varnish No. 410 resists better than the No. 415.

Report of L. P. Nemzek.—The mahogany panels in the case of both varnishes showed no difference on the surface while wet, but upon drying the one coated with varnish No. 410 showed on inspection that it had lost gloss to a very slight extent, while the other remained nearly perfect.

Report of John Dewar.—Mahogany sample, varnish No. 410, light gray in color, disappearing after exposure to air. Down to first coats of varnish soft, can be removed by finger nail, but quickly hardens on exposure. Gloss flattened, surface in bad condition.

Mahogany sample, varnish No. 415, gray in color, disappearing on exposure; varnish quite soft down to first coat, can easily be removed to that depth by finger nail; surface rough, but hardens on exposure.

Report of W. F. Burleigh.—Both show much greater resistance on wood than on tin. The difference found on wood was that varnish No. 410 was softer, and after removal from the water lost considerable luster and fullness. On tin, the time and degree of turning white was the chief difference, and the degree of pitting after removal from the water. Varnish No. 410 softened more and seems to become absorbent, whereas varnish No. 415 remained harder and leathery.

Report of R. W. Lindsay.—On the mahogany panel, varnish No. 410 seemed to be less affected than on the enamel plate, and the only result after being submerged in cold water for a week was that the surface was slightly roughened.

Varnish No. 415 on the mahogany panel was very little affected, there being only small pimples on the surface after being submerged a week.

Report of E. J. Cole.—Both samples stood well, varnish No. 410 somewhat the better. Both samples blued by water. Black tins superior to mahogany panels for this test.

8. HOT-WATER TEST.

Report of F. A. Wertz.—Both varnishes were practically unaffected, showing no whiting or dulling and only a slight impression of the canvas at the rim of the can.

Report of E. C. Holton.—Both samples seemed to be the same in above test, one showing the impression as much as the other.

Report of C. T. Bragg.—Films not materially affected in either case; no tendency to opaqueness or blistering; gloss not destroyed; imprints of duck were visible in spots.

Report of M. Y. Seaton.—Up to five applications of the can of hot water, only slight effect on either of the varnishes was noticed. The test seemed hardly severe enough for the type of varnish.

Report of C. B. Mills.—There was no apparent effect on the surface of each varnish. Only slight impress at rim of can.

Report of F. P. Ingalls.—No marked difference between the varnishes, neither of them showing any great effect.

Report of L. P. Nemzek.—Both panels held up equally well. Neither panel lost the gloss; slight ring at rim.

Report of John Dewar.—Both varnishes gave the same result. Slightly white under rim which disappeared on exposure of rim mark, and slight impression of duck.

Report of R. W. Lindsay.—The varnish was very little affected except where the can pressed on the duck. A distinct impression of the cloth was made showing the outer edge of the can. Practically no difference between the varnishes.

Report of W. F. Burleigh.—The boiling water in the quart cans cooled in two hours. During this time neither panel turned white, but of course, both softened some. The difference at the end of the test was that varnish No. 415 showed considerable deeper impression of the duck than No. 410.

Report of E. J. Cole.—Both samples show impressions on rim of can only; no distinctive differences, would call both good, no white effect.

9. SOAP TEST.

Report of F. A. Wertz.—The varnishes, after 1 min., were whitened and dulled; 5 min., the same; 10 min., the same; 20 min., whitened and dulled, showing blisters; 30 min., the same. Varnish No. 415 did not turn white as quickly as No. 410.

Report of E. C. Holton.—Both samples were white in 10 min. After 40 min., varnish No. 415 was more white than No. 410, but seemed to be more firm.

Report of C. T. Bragg.—Both samples became turbid at the end of 10 min., varnish No. 410 being more white than No. 415. Varnish No. 410 showed blisters; No. 415 also showed blisters, but film was stronger.

Report of M. Y. Seaton.—Both varnishes gave about the same result; varnish No. 415 remained while No. 410 disintegrated.

Report of C. B. Mills.—Both panels became cloudy at the end of 10 min. It was noted that varnish No. 410 was more disintegrated than No. 415.

Report of F. P. Ingalls.—Both varnishes gave about the same result. Varnish No. 410 appeared to have retained its gloss somewhat better than No. 415.

Report of L. P. Nemzek.—Both varnishes gave the same result except that after one hour varnish No. 410 had blistered badly. Both lost their gloss.

Report of John Dewar.—Both varnishes gave same result. Both disintegrated at end of 30 min.

Report of R. W. Lindsay.—After 10 min., the first coat of varnish No. 410 was almost removed. After 20 min., the first coat of varnish was completely removed, and second coat attacked. After 30 min., the second coat was completely removed and enamel and coating on metal plate softened.

After 10 min., first coat of varnish No. 415 turned gray and softened. After 20 min., first coat of varnish started to curl at the edges; varnish was almost white. After 30 min., both coats softened all over and varnish removed around the edges.

Report of W. F. Burleigh.—Both softened very rapidly and took on an opaque soapy look very soon after immersion. After 10 min. both were very soft. On the side of the tin not coated with black, both varnishes had left the tin. After 20 min., both affected to a worse degree. After 30 min. varnish No. 410 was lifting in sheets, but No. 415 was a little harder, more leathery, and still adhered to the tin unless removed by the nail. Twenty-four hours after removal from the water, both had a silky semi-gloss and had recovered hardness to some extent, but lacked life. The test is too severe as it destroys both the varnishes to a great extent.

Report of E. J. Cole.—After 30 min. both samples turned white, varnish No. 410 becoming rougher than No. 415. After 40 min., varnish No. 410 still worse, although No. 415 showed the beginning of large wrinkles. After 1 hr., No. 415 was much the worse, having loosened from the plate so that the black enamel began to be attacked.

10. WEATHER TEST.

Report of F. A. Wertz (Washington, D. C.).—After 14 weeks, no change was noticed.

Report of E. C. Holton (Cleveland, O.).—After 4 months both panels in good condition. Varnish No. 410 slightly better than No. 415.

Report of C. T. Bragg (Mansfield, O.).—After 4 months, no change.

Report of Allen Rogers (Brooklyn, N. Y.).—After 4 months, varnish No. 415 was better than No. 410.

Report of M. Y. Seaton (Cleveland, O.).—After 4 months, both panels in perfect condition.

Report of C. B. Mills (Brooklyn, N. Y.).—After 4 months, both panels in perfect condition.

Report of F. P. Ingalls (Brooklyn, N. Y.).—After 3 months, varnish No. 415 seriously disintegrated. Varnish No. 410 still in good condition, although somewhat dull.

Report of L. P. Nemzek (Gibbsboro, N. J.).—After one month, no change was noted in either panel.

Report of R. W. Lindsay (Buffalo, N. Y.).—Both varnishes were applied to panels as directed and exposed to the weather January 27, 1917, and on being examined April 6, 1917, were found to show no signs of deterioration and in fact were in very good condition.

Report of W. F. Burleigh. (Newark, N. J.)—After one month, no change. In 7 weeks varnish No. 410 was in perfect condition, but No. 415 developed short, wide, stubby checks extending in all directions.

Report of E. J. Cole (Brooklyn, N. Y.).—Varnish No. 415 showed no cracks and had good luster after 6 months' exposure. Varnish No. 410 showed signs of cracking after 4 months' exposure. Quite a number of cracks from 6 months, although luster is fair.

REPORT OF SUB-COMMITTEE XI ON PAINT THINNERS OTHER THAN TURPENTINE.

The work of Sub-Committee XI during the past year has dealt entirely with methods for determining flash-point. The problem of selecting the most suitable form of flash-point tester has necessitated a far more extensive investigation than the sub-committee anticipated when the work was undertaken. The work has involved making more than 1300 tests.

One set of investigations has led to another until a large volume of data has been accumulated, which the sub-committee feels is too valuable to permit being lost through lack of publication

A rather complete record of the investigations conducted on flash-point testers, and a full account of the activities in this line, are therefore presented.

Problem.—The problem which presented itself was to determine the relative reliability and suitability of the many types of testers in more or less general use, and in the light of this information, to select or devise one best suited to the needs of manufacturers and users of volatile and inflammable materials of the class with which this sub-committee deals.

Committees Cooperating.—No sooner had the work of the sub-committee been started and information concerning its activities spread abroad, than three committees of as many organizations who were investigating the same problem came forward, offering to cooperate with the sub-committee, with a view to securing uniform action, by all the organizations represented and other committees of this Society, in the selection and adoption of standard methods and apparatus for flash-point determinations. These committees represented the National Paint, Oil & Varnish Association, The Paint Manufacturers' Association of the United States, and the National Varnish Manufacturers' Association. The Underwriters' Laboratories was also represented on the sub-committee. These organizations are interested in the flash-point test, both as a physical test of the materials themselves and as a means of determining fire hazard under city, state and Federal laws.

Canvass of Testers.—Before making decision as to which of the various flash-point testers to consider, a canvass was made of all the laboratories known to the sub-committee, to ascertain what testers were in general use. About 200 laboratories were canvassed and replies were received from approximately one-half of them. Seventy-two laboratories gave details of their testers, and of these laboratories, 43 expressed their willingness to co-operate in making tests. Table I shows the number and kind of testers available.

TABLE I.—DATA RELATIVE TO AVAILABLE TESTERS.

Name of Tester.	Total Number of Testers in the 72 Laboratories.	Total Number of Testers in the 43 Laboratories Willing to Cooperate in the Work.
Tagliabue Open	45	24
Elliott or New York State	39	23
Abel-Pensky	20	9
Pensky-Martens	10	7
Cleveland	6	6
Abel	8	4
Scott	4	3
Saybolt	2	2
Special Types	15	7

Basis of Selection of Testers.—A study of Table I shows eight types of testers in use in this country, and in addition a number of special testers which have either been constructed by the individual laboratory or are a modification of some existing tester. Of the types in general use the Tagliabue Open and the Elliott are by far the most numerous, and for this reason were included.

The Abel and the Abel-Pensky are the English and German standard testers, respectively, and therefore are much used in this country in testing materials for export, and for this reason were included.

The Pensky-Martens and Cleveland Testers are used only for high-flash-point oils.

The Scott and Saybolt testers have not established themselves as legally adopted standards for paint thinners. Therefore, the last four named testers were not included in these tests.

It was the endeavor to select from those laboratories willing to cooperate with the sub-committee, only those having two or more of the four different types of testers chosen for investigation, so that a direct comparison of results would be possible. Twenty-five such laboratories which were in position to make immediate tests were selected and samples submitted to them.

Procedure.—In order to make comparative tests of the instruments under consideration a standard sample of mineral spirits was selected and 1-gal. cans were filled and sealed by the sub-committee and sent to each of the laboratories.

A carefully prepared set of directions was drawn up covering in detail the operation of each of the testers. In the cases of the Tagliabue Open, the Abel, and the Abel-Pensky testers, two methods of operation were prescribed.

The general features of these two methods of operation, in the case of the Tagliabue Open tester, were as follows:

In method No. 1, the test was conducted as is usual, applying the testing flame by passing it horizontally across the top of the cup.

In method No. 2 the test was similar to that of method No. 1, except that the testing flame was lowered to the top of the cup at three points around its circumference.

For the Abel and the Abel-Pensky testers, method No. 1 was the official one prescribed for these testers, in which the water in the bath is heated to a predetermined temperature before introducing the oil for test. Method No. 2, which was proposed for investigation by the sub-committee, varied the procedure by heating the water bath while the test was in progress, at such a rate that the oil sample would rise in temperature at the rate of 1° C. per minute.

Detailed directions for this series of tests are given in Appendix I to this report.

Results of 1914 Tests.—The laboratories cooperating numbered 35 with a total of 64 operators. The laboratory averages of the tests are given in Table II.

Details of tests are also given in Appendix I to this report.

A study of the results of this series developed a wide diversity in the flash-points obtained with the open tester, and the reports showed that there was a great variation in the weight and capacity of the glass oil cups used (weight varied from 72 to 108 g. and capacity from 67 to 100 cc). It therefore seemed impractical to compare flash-points obtained with such widely differing apparatus.

It was decided therefore to conduct a new series of tests by members of the sub-committee, using in the open type of testers glass cups of uniform size, weight and capacity, and also a uniform metal cup. An opportunity was also found at this time to include tests with the Bureau of Mines Model tester, which was not available at the beginning of the 1914 series of tests.

TABLE II.—LABORATORY AVERAGES OF FLASH-POINT TESTS; 1914 SERIES.

VALUES IN DEGREES CENTIGRADE.

Name of Tester.	Method No.	Laboratory Averages.			
		All.	Lowest.	Highest.	Difference.
Tagliabue (Open)	1	41.3	38.5	47.7	9.2
	2	37.9	36.4	41.2	4.8
Elliott (Closed)	..	32.3	31.0	33.5	2.5
Abel (Closed)	I	32.2	29.5	33.9	4.4
	II	32.4	31.0	33.5	2.5
Abel-Pensky (Closed)	I	34.5	33.4	35.8	2.4
	II	34.5	33.4	36.3	2.9

Tests of 1915 Series.—A supply of glass and metal cups was secured and calibrated by the sub-committee as to weight and capacity, and were found to be within satisfactory limits. The table of complete calibration results is given in Appendix II to this report.

In order to secure results over a wider range, samples of three liquids were used having flash points of about 24° C. (75° F.), 38° C. (100° F.) and 50° C. (122° F.), respectively.

The methods for operating the Tagliabue Open tester were similar to those used in the 1914 series using both method Nos. 1 (sweep) and 2 (dip) for applying the test flame.

The method of operating the Bureau of Mines Model tester was that furnished with the apparatus.

A detailed description of the procedure for this series of tests is given in Appendix II to this report.

The laboratory averages of the tests are given in Table III.

TABLE III.—LABORATORY AVERAGES OF FLASH-POINT TESTS; 1915 SERIES.

VALUES IN DEGREES CENTIGRADE.

SAMPLE NO. 1.

Name of Tester.	Kind of Cup.	Method No.	Laboratory Averages.			
			All.	Lowest.	Highest.	Difference.
Tagliabue (Open)...........	Glass.........	1	41.3	38.0	45.2	7.2
	Metal........	1	41.4	39.8	43.7	3.9
	Glass.........	2	38.4	36.5	40.7	4.2
	Metal........	2	37.9	35.7	40.2	4.5
Abel-Pensky (Closed).........	....	..	34.6	33.3	35.4	2.1
Bureau of Mines (Closed).....	....	..	34.2	33.0	35.5	2.5
SAMPLE NO. 2.						
Tagliabue (Open)...........	Glass.........	1	27.4	25.0	30.1	5.1
	Metal........	1	27.4	25.3	30.2	4.9
	Glass.........	2	24.2	22.6	25.6	3.0
	Metal........	2	24.0	22.3	24.8	2.5
Abel-Pensky (Closed).........	....	..	22.1	21.2	22.6	1.4
Bureau of Mines (Closed).....	....	..	21.5	20.7	22.5	1.8
SAMPLE NO. 3.						
Tagliabue (Open)...........	Glass.........	1	52.4	49.0	55.5	6.5
	Metal........	1	52.9	49.9	56.3	6.4
	Glass.........	2	49.1	46.0	52.7	6.7
	Metal........	2	48.6	45.6	50.6	5.0
Abel-Pensky (Closed).........	....	..	45.5	44.5	46.6	2.1
Bureau of Mines (Closed).....	....	..	45.5	44.2	46.6	2.4

The details of all tests of this series are given in Appendix II to this report.

A survey of these results shows that with the Tagliabue Open tester, the difference between results from various laboratories, even when all the refinements which seemed feasible were applied to the apparatus and methods of operation, was still approximately twice as great as with the several closed types of testers. This difference, amounting to from about 3 to about 5° C. or more, is greater than can be allowed in commercial practice, and this fact of itself eliminated from further consideration the adoption of the open type of tester as a standard instrument.

Comparing the results obtained with all of the closed testers in both the 1914 and 1915 series, it is noted that all show about the same difference between various laboratory averages, this difference ranging from about 1.5 to about 3° C. It therefore seemed to the sub-committee that as the Abel, Abel-Pensky, and Bureau of Mines Model testers were all of costly design, it might be possible to produce a simple and less expensive form of tester which would be acceptable to replace the many and varied types of testers now in use.

The Elliott tester, while simple and inexpensive, unfortunately requires a large quantity of oil. This quantity is about that necessary to fill a kerosene lamp of medium size or 10 oz. As a number of tests must be made for check purposes, the quantity of oil required is much more than is often available for test. This type of tester is therefore not suited for adoption as a standard.

The Tagliabue Open tester, in spite of its inaccuracy, is in such general use and is so generally specified in the laws of various states and cities, undoubtedly on account of its cheapness, that the sub-committee felt that by modifying this type to make it a closed tester, one reasonably accurate and of low cost might be produced.

The modified tester, called the Tag Closed tester, was tried out by a number of the sub-committee members in 1916, and the results as to accuracy were so satisfactory that after further improvement of the tester, a new series of tests was outlined for 1917, to compare the new form of Tag Closed tester with the older forms of closed testers of recognized accuracy.

These preliminary results with the Tag Closed tester showed that it was possible, within certain limits, to control the flash point by varying the dimensions of the oil cup—especially the depth of the cup—and the amount of oil used in making the test

A 50-cc. sample was chosen as a convenient size for test because of ease of measurement, and because it requires but a moderate amount of the usual sample for the flash-point test, which in many cases is only one of the several tests for which the sample is to be used.

Tests of 1917 Series.—For the 1917 series, five samples of oils flashing about 22° C. (72° F.), 30° C. (86° F.), 35° C. (96° F.), and 64° C. (147° F.), and three types of liquids, namely, coal tar, petroleum distillates, and turpentine were used.

Results were received from 13 investigators, 8 of which were sub-committee members, and 4 were of the cooperating laboratories which assisted in the 1914 tests. All of the laboratories were equipped with Abel-Pensky testers with which to compare the new Tag Closed tester. The Abel-Pensky tester was chosen for comparison because it is in much more general use, among the laboratories carrying on this investigation, than the Abel tester.

A detailed description of the procedure for this series of tests is given in Appendix III to this report.

The laboratory averages of tests are given in Table IV.

The details of tests for this series are given in Appendix III to this report.

The data show that the difference between the highest and lowest laboratory averages for the Abel-Pensky tester ranges as a rule between 2 and 3° C., while for the Tag Closed tester this difference is approximately the same.

Conclusions.—On the basis of these results, the Tag Closed tester is shown to be as accurate and subject to as little variation in results as the Abel-Pensky tester, which was chosen as the best representative of the closed type.

It will also be observed that the average of the results obtained with the Tag Closed tester is about a mean between the results obtained with the Abel and the Abel-Pensky testers. The Elliott tester gives results agreeing very closely with the Abel. Comparative figures on sample No. 1 which was used in all of the tests show the following relation:

	FLASH POINT, DEG. CENT.
Elliott, closed; 1914 series	32.3
Abel, closed; 1914 series	32.3
Abel-Pensky, closed; 1914, 1915 and 1917 series	34.4
Tag, closed; 1917 series	33.3

These results show that the Tag Closed, Abel, and Abel-Pensky testers give sufficiently concordant results to warrant their use as standard testers.

In view of the several differences in results obtained with different types of testers, especially between the open and closed testers, it is obviously important that in reporting flash-point tests, the type and name of tester used shall be stated.

TABLE IV.—LABORATORY AVERAGES OF FLASH-POINT TESTS; 1917 SERIES.
VALUES IN DEGREES CENTIGRADE.

Name of Tester.	Laboratory Average.			
	All.	Lowest.	Highest.	Difference.
SAMPLE No. 70 *N*.				
Tag Closed	21.8	20.4	22.7	2.3
Abel-Pensky	22.3	20.9	23.7	2.8
SAMPLE No. 80 *B*.				
Tag Closed	30.3	29.2	31.3	2.1
Abel-Pensky	30.9	29.3	32.5	3.2
SAMPLE No. 1 *S*.				
Tag Closed	33.3	32.2	35.3	3.1
Abel-Pensky	34.2	32.8	35.0	2.2
SAMPLE No. 100 *T*.				
Tag Closed	33.2	32.1	34.3	2.2
Abel-Pensky	34.0	32.8	35.7	2.9
SAMPLE No. 150 *D*.				
Tag Closed	61.2	60.4	62.0	1.6
Abel-Pensky	63.7	63.2	64.6	1.4

It is the intention of the sub-committee to present, in the near future, a proposed tentative method for the determination of the flash point of paint thinners other than turpentine, which method will employ the Tag Closed tester. Before this can be done it will be necessary to standardize this instrument, and this work is in progress.

Respectfully submitted on behalf of the sub-committee,

CLOYD M. CHAPMAN,
Chairman.

APPENDIX I.

TESTS OF 1914 SERIES.

The following directions for the 1914 series of tests were sent to every member of the sub-committee:

Testers.—The testers used are shown in Figs. 1, 2, 3 and 4. The interior arrangement of the Abel-Pensky tester is not shown, but is similar to that of the Abel tester as shown. Information relating to the Abel and Abel-Pensky testers and their standardization is given in "A Treatise on Petroleum," by B. Redwood.

Thermometers.—The thermometers used with the Tagliabue Open and Elliott testers shall be in accordance with the following specifications:[1]

The thermometer shall be graduated from −10 to +110° C. in intervals of 1° C. There shall be a small reservoir above the 110° C. mark. The thermometer shall be finished at the top with small glass ring.

The stem shall be made of enamel backed thermometer tubing, but not of Jena 16^{III} glass. The bulb shall be made of Jena 16^{III}, Corning normal, or Jena or Corning borosilicate glass.

Every fifth graduation shall be longer than the intermediate ones and the marks shall be numbered at every even interval of 10°. The graduation marks shall be clear cut and fine, and the numbering clear and distinct.

Each thermometer shall be provided with a suitable case. A serial number for identification shall be engraved on the stem.

All material and workmanship shall be of the best grade.

The maximum error at any point shall not exceed 0°.3 C.

The thermometer shall conform to the following dimensions:

Total length, max., mm.	300
Diameter of stem, mm	5.5 − 7.0
Diameter of bulb	5.5 − 7.0
Diameter of capillary, min., mm	0.1
Length of bulb, mm	8 − 12
Distance, −10° to bottom of bulb, mm	40 − 60
Distance, −10° to 110° mark on scale, mm	180 − 220

Directions for Operating Tagliabue Open Tester.

Test shall be made in a room partially darkened.

The tester shall be protected by a surrounding screen, 16 in. square, 30 in. high, open at top and front, and painted black inside. Drafts caused by the breath of the operator shall be carefully avoided.

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[1] These standard thermometers were furnished by the sub-committee for use with the above-mentioned testers. The thermometers used in the Abel and Abel-Pensky testers were those belonging with the instruments.

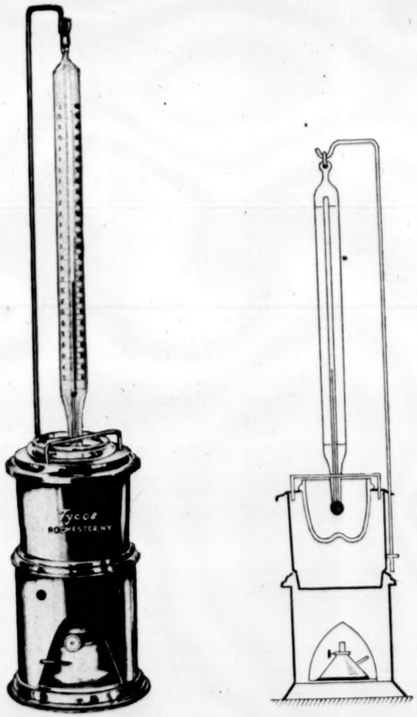
Tycos
ROCHESTER, N.Y.

FIG. 1 —Tagliabue Tester.

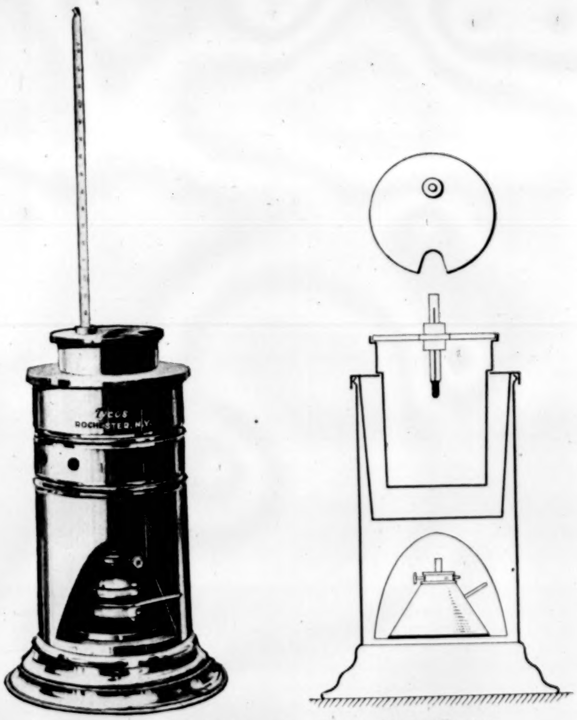
Tycos
ROCHESTER, N.Y.

FIG. 2.—Elliott or New York State Tester.

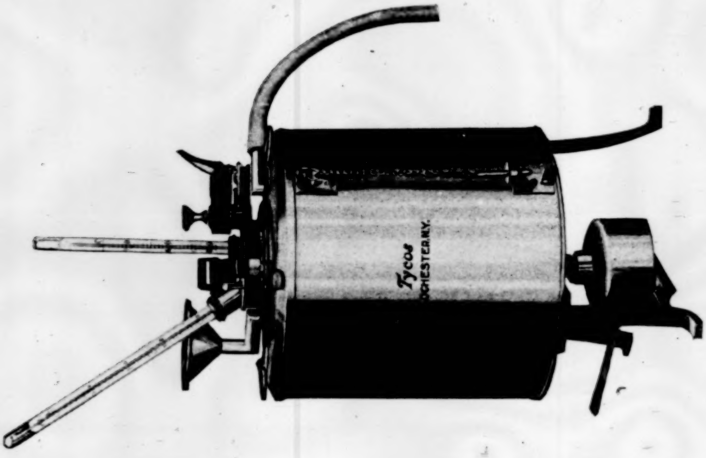
Tycos
ROCHESTER, N.Y.

FIG. 4.—Abel-Pensky Tester.

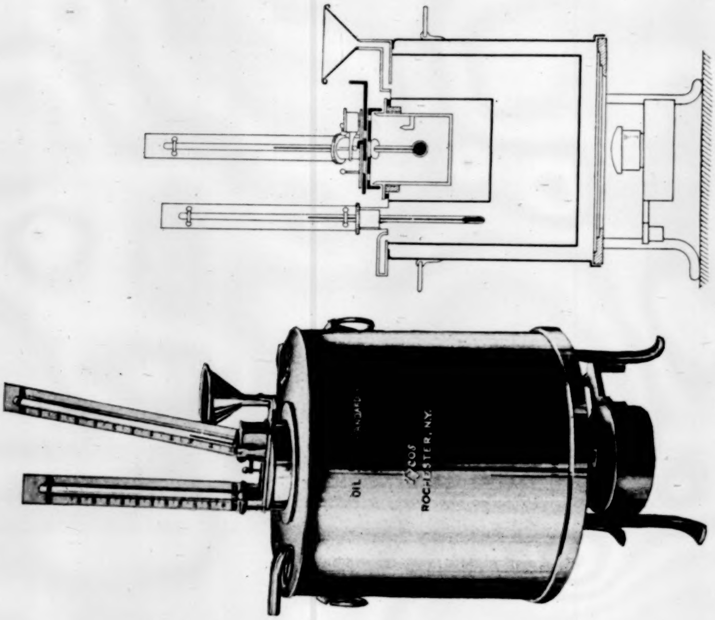
OIL
Tycos
ROCHESTER, N.Y.

FIG. 3.—Abel Tester.

A fresh sample shall be used for each test.

The instrument must stand level.

Barometer readings shall be made at time of test.

Preparation of Water Bath.—Fill the metal bath with water at a temperature of 25° C. (77° F.), so that when the glass cup is in place, the water in bath will come to the rim of the metal cup.

Preparation of Sample.—Suspend a calibrated thermometer (see specifications) in the center of the cup with the top of the bulb of same ½ in. below the upper level edge of the glass cup. Bring the sample to be tested to a temperature of 15.°5 C. (60° F.). Fill the glass cup with 59 cc. of the sample. See that there is no oil on the outside of the cup or its upper edge, using a filter paper to clean the cup. Remove air bubbles, if any, from the surface of the oil.

NOTE.—The horizontal flashing-taper guide wire (as specified in the directions of the manufacturer) is not to be used in these tests.

Application of Heat to Oil Cup.—Heat the bath with an alcohol, gas or other flame, so adjusted that the temperature will not be raised faster or much slower than 1° C. (1.°8 F.) per minute, without removing the flame.

Description of Test Flame.—The test flame shall be spherical in form, and shall have a diameter equal in size to the bead furnished herewith, which may be attached to the cover of the water bath. This flame is best produced by passing gas through a straight, thin-metal blow-pipe tube[1] or Tagliabue special tube.

Initial Test.—When the sample under test reaches a temperature of 30° C. (86° F.) the first test shall be made, and tests shall be made thereafter at each rise of 1° C. (1.°8 F.) until the flash point is reached.

Method of Applying Test Flame.—Both of the following two methods are to be used and reported on:

1. *Sweep Method.*—Holding the burner tube in a truly horizontal position, the flame is passed in a straight line continuously across the center of the cup, with the tube touching the edge of the cup. The time for one sweep from edge to edge of the cup to be gaged to one second. The temperature at which a flame first appears anywhere on the surface of the oil shall be considered the flash point.

2. *Dip Method.*[2]—Holding the burner tube in a vertical position with the flame 3 in. above the surface of the sample, the flame is quickly lowered to ⅛ in. from the surface of the sample near the outer edge of the cup, and withdrawn; entire operation consuming one second. This operation is quickly repeated at three equi-distant points around the circumference of the cup. The temperature at which a blue flame jumps from the taper to the surface of the oil is the flash point.

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[1] See Eimer and Amend, catalogue C, 1913, p. 54, item 784; or Scientific Materials Co., 1912, p. 69, item 618.

[2] A special burner tube was supplied by the sub-committee for use in the Dip method. This special tube was provided with a guard ring on the burner end, so arranged that when the tube was brought down in a vertical position till the guard ring came into contact with the top of the oil cup, the flame would be at the required distance above the surface of the oil.

Directions for Operating the Elliott or New York State Tester.

Test shall be made in a room partially darkened.

The tester shall be protected by a surrounding screen, 16 in. square, 30 in. high, open at top and front, and painted black inside. Drafts caused by the breath of the operator shall be carefully avoided.

A fresh sample shall be used for each test.

The instrument must stand level.

Barometer readings shall be made at time of test.

Preparation of Water Bath.—Fill the metal bath with water at a temperature of 25° C. (77° F.), so that when the metal cup is in place, the water in bath will come to the rim of the metal bath.

Preparation of Sample.—Bring the sample to be tested to a temperature of 15.°5 C. (60° F.). Fill the metal cup with the sample to such a point that the surface of the oil will be ⅛ in. below the lower inner flange. Remove air bubbles, if any, from the surface of the sample. Place the glass cover in position and insert a calibrated thermometer (see specifications) through the cork in the central opening so that the top of the bulb will be ¼ in. below the surface of the sample.

Application of Heat to Oil Cup.—Heat the bath with an alcohol, gas or other flame, so adjusted that the temperature will not be raised faster or much slower than 1° C. (1.°8 F.) per minute, without removing the flame.

Description of Test Flame.—The test flame shall be spherical in form, and shall have a diameter equal in size to the bead furnished herewith, which maybe attached to the cover of the water bath. This flame is best produced by passing gas through a straight, thin-metal blow-pipe tube,[1] or Tagliabue special tube.

Initial Test.—When the sample under test reaches a temperature of 25° C. (77° F.) the first test shall be made. Tests shall be made thereafter at each rise of 1° C. (1.°8 F.) until the flash point is reached.

Method of Applying Test Flame.—Holding the burner tube at an angle of 45 deg., the flame is passed through the side opening in the cover to a point half-way between the surface of the sample and the cover. The time consumed in entering and withdrawing the flame is to be one second. The temperature at which a blue flame is seen through the glass is the flash point.

Directions for Operation of Abel-Pensky Tester.

Two methods, both of which are to be used and reported on, are given herewith. They consist of (I) a translation of the Official Method of the Imperial Technical Bureau, and (II) the Sub-Committee Experimental Method.

I. Official Method.

A. Preliminary Operations.

1. *Choice of Laboratory.*—A place free from drafts in a room which is kept at a temperature of 18 to 20° C. (64 to 68° F.) should be chosen for testing petroleum.

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[1] See Eimer and Amend, catalogue C, 1913, p. 54, item 784; or Scientific Materials Co., 1912, p. 69, item 618.

2. *Sampling.*—The petroleum samples should be kept in a closed container in the testing room up to the time the testing is to take place.

3. *Barometric Readings.*—Before starting the testing, the metal barometer in the carrying case of the apparatus, or a mercury barometer in the testing laboratory itself, should be read in millimeters (no decimal parts), and on the basis of this reading, the temperature of the petroleum (see Section 13) at which testing should be started with the first opening of the slide determined by means of the following:

BAROMETER READING.	TEMPERATURE TO START TESTING. DEG. CENT.	TEMPERATURE TO START TESTING. DEG. FAHR.
640 – 670 mm. (25.20 – 26.38 in.)	13	55
670 – 700 " (26.38 – 27.56 ")	14	57
700 – 730 " (27.56 – 28.74 ")	15	59
730 – 760 " (28.74 – 29.92 ")	16	61
760 – 790 " (29.92 – 31.10 ")	17	63

4. In the case of kinds of petroleum which have a high flash point, the approximate temperature at which these oils flash is determined in a preliminary test and then the actual test is started about 5 to 7° C. (9 to 13° F.) lower than the flash point.

5. After the operations described in Section 3 have been carried out, the petroleum container is set up on a level and horizontal bench, in such a way that the red mark on the thermometer, which dips in the water container, is on a level with the eye and the whole stands upright.

6. *Preparation of Water Bath.*—The water container is filled with water up to the point where it starts to flow out through the overflow tube. For kinds of petroleum which flash between 19 and 25° C. (66 and 77° F.), this water should be at a temperature of 50 to 52° C. (122 to 126° F.), while in the case of oils flashing between 25 and 35° C. (77 to 95° F.) it should have a temperature of 60 to 63° C. (140 to 145° F.). (Compare with Section 9.)

If instead of doing this, the water is brought up to the desired temperature in the tester itself by means of the spirit lamp which accompanies it, or by a gas burner or some similar means, then any overheating of the carrying ring set on the tripod should be avoided.

7. *Preparation of Ignition Lamp.*—The ignition lamp, which has a round braided wick, is filled with loose cotton batting and petroleum is allowed to drip on to this cotton, until both the cotton and the wick are saturated. The excess of petroleum is removed by filter paper, but the cotton is allowed to remain in the lamp. The end of the wick should be cleaned of all soot and impurities.

8. *Preparation of Oil Cup and Sample.*—The petroleum container and its cover, together with the thermometer which belongs to this part of the apparatus, are all thoroughly cleaned and dried with filter paper.

Thereupon, the petroleum is cooled to such a point that the testing can be started at the temperature which has been determined in Section 3. The container must be brought to this same temperature, and in case it is dipped into water for this purpose, it must once more be carefully dried without the temperature being increased to any appreciable extent by this operation.

B. Testing.

9. *Application of Heat to Water Bath.*—After completion of all preparations and after the water bath has received sufficient preliminary heating, it is heated by means of the spirit lamp, to a temperature of 55° C. (131° F.) for oils which flash between 19 (66° F.) and 25° C. (66 and 77° F.) or 65° C. (149° F.) for oils flashing between 26 and 35° C. (79 and 95° F.). During the entire course of the test, the water bath is kept at this temperature.

10. *Final Preparation of Oil Cup.*—After this, the container is slowly filled with petroleum by means of a pipette and this is so controlled that no bubbles are formed, and sufficient petroleum is allowed to run in to just cover the point of the filling mark. Under all circumstances, wetting of the sides of the container above the mark is to be avoided. If, in spite of all precautions, this does happen, the container should be emptied, carefully dried and filled once more with fresh petroleum.

The container is covered immediately after it is filled.

11. *Immersion of Oil Cup.*—The filled container is thereupon immersed into the water bath, care being taken that the petroleum is not shaken about. Before this is done, it must be seen that the water bath has the temperature given in Section 9, and if necessary this is obtained by the addition of small quantities of hot or cold water, as the case may be.

12. *Final Preparation of Ignition Lamp.*—As soon as the temperature of the petroleum in the petroleum container approximates the temperature determined by Section 3, the lamp is lighted and the flame is regulated in such a way that it is equal to the little white ball on the cover of the container. In addition the screw is wound by turning the head in the direction of the arrow until it is tight.

13. *Application of Test; Repetition of Test.*—As soon as the petroleum has reached the temperature necessary for beginning the testing, the release pin is pressed, whereupon the slide is put into slow and uniform motion which is completed in two seconds. During this time the behavior of the surface of the petroleum which is near the flame is watched. After the screw has come to rest, it is wound up again and the preceding operation is repeated as soon as the thermometer in the petroleum container rises 0.°5 C. (0.°9 F.). This is kept up at every 0.°5 C. (0.°9 F.) until flashing ensues.

The ignition flame will be slightly increased by a kind of light veil at about the flash point but only the lightning-like formation of a large, blue flame which stretches over the entire open surface of the petroleum, can be taken as the end of the test, and even that with only the extinguishing of the light, which is caused in most cases by the flash.

The temperature, read on the (oil cup) thermometer, at which flashing takes place, corrected for the thermometer in question, gives the flash-point under the given conditions of the petroleum being tested.

C. *Repetition of Test.*

14. After the first test, a check must be run in just the same way as described above, but with another quantity of petroleum. For this purpose, the heated cover of the container is first allowed to cool in water, during which time the container is emptied, dried and filled once more.

The thermometer which dips into the container and the cover must be dried very carefully with filter paper before refilling, and especially all petroleum which may have remained on the slide opening or the lamp must be removed.

If necessary, before the immersion of the container in the water-bath, the latter is once more brought to the requisite temperature described in Section 9.

15. *Number of Necessary Repetitions.*—If the second test gives a flash point which differs from that found in the first by no more than 0.°5 C. (0.°9 F.), the average of the two is taken as the temporary flash-point; that is, as that temperature at which flashing takes place under the given barometric conditions.[1]

If the difference between the two results is 1° C. (1.°8 F.) or more, then another repetition of the test is necessary. If, between the three determinations, there are no greater differences than 1.°5 C. (2.°7 F.) then the average of the three results may be considered as the temporary flash-point.

II. SUB-COMMITTEE EXPERIMENTAL METHOD.

Test shall be made in a room partially darkened.

The tester shall be protected by a surrounding screen, 16 in. square, 30 in. high, open at top and front, and painted black inside. Drafts caused by the breath of the operator shall be carefully avoided.

A fresh sample shall be used for each test.

The instrument must stand level.

Preparation of Water Bath.—Fill the water bath with water through the funnel, until the water begins to flow out through the overflow pipe. The temperature of the water at the commencement of each test shall be 25° C. (77° F.). The air bath surrounding the oil cup shall be clean and dry.

Preparation of Test Flame.—Saturate the cotton in the lamp reservoir with lard oil, and adjust the wick to give a flame equal in size to the small ivory bead mounted on the cover.

Preparation of Oil Cup.—Cool the cup to a temperature of 15.°5 C. (60° F.). Place the cup in a level position, in good light, and fill with the sample which has previously been brought to a temperature of 15.°5 C. (60° F.), until the surface of the liquid is level with the point of the gage, which is fixed in the cup. Remove air bubbles, if any, from the surface of the oil. Place the cover, into which has been properly inserted the thermometer supplied with the machine, on the sample cup, care being taken that the cover is pressed down so that its edge rests on the rim of the cup.

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[1] The method of applying correction for barometric pressure, together with directions for using the check rule, is not given herewith, as the sub-committee will make all barometric corrections.

Application of Heat to Oil Bath.—Heat the bath with an alcohol, gas or other flame, so adjusted that the temperature of the sample will not be raised faster or much slower than 1° C. (1.°8 F.) per minute, without removing the flame.

Initial Test.—When the sample under test reaches a temperature of 25° C. (77° F.) the first test shall be made. Tests shall be made thereafter at each rise of 0.°5 C. (0.°9 F.).

Method of Applying Test Flame.—Test flame is lighted, noting carefully that the flame is the size of the ivory bead. The clock work is wound by turning the key as far as possible to the right. When the temperature is reached at which test is to be made (25° C. or 77° F.), the clock work is set in motion by pressing the trigger. Before each test the clock work should be wound and the test flame adjusted to proper size, if necessary.

Flash Point.—The flash point is indicated by a slight explosion.

DIRECTIONS FOR OPERATION OF ABEL TESTER.

Two methods, both of which are to be used and reported on, are as follows: (I) A translation of the official method of the Imperial Technical Bureau (see operation of Abel-Pensky tester), and (II) the Sub-Committee Method. The latter is given herewith.

II. SUB-COMMITTEE METHOD.

Test shall be made in a room partially darkened.

The cup shall be protected by a surrounding screen, 16 in. square, 30 in. high, open at top and front, and painted black inside. Drafts caused by the breath of the operator shall be carefully avoided.

A fresh sample shall be used for each test.

The instrument must stand level.

Preparation of Water Bath.—Fill the water bath with water through the funnel, until the water begins to flow out through the overflow pipe. The temperature of the water at the commencement of each test shall be 25° C. (77° F.). The air bath surrounding the oil cup shall be clean and dry.

Preparation of Test Flame.—Saturate the cotton in the lamp reservoir with lard oil and adjust the wick to give a flame equal in size to the small ivory bead mounted on the cover.

Preparation of Oil Cup.—Cool the cup to a temperature of 15.°5 C. (60° F.). Place the cup in a level position, in a good light. Fill with the sample, which has previously been brought to a temperature of 15.°5 C. (60° F.) until the surface of the liquid is level with the point of the gage, which is fixed in the cup. Remove air bubbles, if any, from the surface of the oil. Place the cover, into which has been properly inserted the round bulb thermometer supplied with the machine, on the sample cup, care being taken that the cover is pressed down so that its edge rests on the rim of the cup.

Application of Heat to Water Bath.—Heat the bath with an alcohol, gas or other flame, so adjusted that the temperature of sample will not be raised faster or much slower than 1° C. (1.°8 F.) per minute, without removing the flame.

Initial Test.—When the sample under test reaches a temperature of 25° C. (77° F.) the first test shall be made. Tests shall be made thereafter at each rise of 0.°5 C. (0.°9 F.).

Method of Applying Test Flame.—Test flame is lighted, noting carefully that the flame is the size of the ivory bead. When the temperature is reached at which test is to be made (25° C. or 77° F.), the test flame is applied in the following manner:[1]

The slide is drawn open while the pendulum (measuring 24 in. from the point of suspension to the center of gravity of the weight), supplied with each apparatus, performs three oscillations, and closed during the fourth oscillation. By one oscillation is meant the passage of the ball of the pendulum from the greatest distance from the vertical on the one side to the greatest distance from the vertical on the other.

Flash Point.—The flash point is indicated by a slight explosion.

RESULTS OF TESTS.

Tables I to IX, inclusive, give the results of the tests of the 1914 series of flash-point determinations. The tests are numbered for reference purposes only.

TABLE I.—RESULTS OF TESTS WITH TAGLIABUE OPEN TESTER.

Test No.	Laboratory.	Operator.	Weight of Cup, g.	Capacity of Cup, cc.	Method No. 1. (Sweep Method) Rise in Temperature per Minute during Test, deg. Cent.	Method No. 1. (Sweep Method) Flash Point,[a] deg. Cent.	Method No. 2. (Dip Method.) Rise in Temperature per Minute during Test, deg. Cent.	Method No. 2. (Dip Method.) Flash Point,[a] deg. Cent.
1[b]	Atlantic Refining Co.	J. C. H.	75.2	82	1.0	44.5	1.0	39.5
2	C. V. Bacon.....	C. V. B.	99.5	74	1.0	43.0	1.0	38.0
3			99.5	74	0.7	43.5	0.9	37.9
4			99.5	74	1.2	42.9	...	....
5			99.5	74	1.0	43.4	...	....
6		I. P. M.	99.5	74	1.0	44.0	1.0	38.0
7			99.5	74	0.7	43.9	1.1	37.0
8			99.8	74	0.9	42.9	...	....
9[b]	Barber Asphalt Paving Co.....	H. P. H.	77.4	82	1.2	41.6	1.1	37.6
10			77.4	82	1.2	41.8	1.0	36.8
11		C. L. W.	77.4	82	1.0	36.6	1.0	35.6
12			77.4	82	1.1	40.8	1.1	37.8
13	Barrett Co.......	J. M. W.	72.4	83	1.0	42.8	0.9	40.8
14		C. R. D.	72.4	83	1.1	44.8	1.0	38.9
15			72.4	83	0.9	39.9	1.0	37.9
16		W. G. D.	72.4	83	1.1	43.8	1.1	38.9
17			72.4	83	1.0	39.9	1.1	38.9

[a] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

[b] The specified thermometer was not used, but the thermometer described by operator appears to be satisfactory.

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[1] Some of the more recent Abel testers are provided with clock work, such as is used in the Abel-Pensky tester, in which case the method of applying flame would be the same as that outlined for Abel-Pensky tester.

TABLE I.—RESULTS OF TESTS WITH TAGLIABUE OPEN TESTER (*Continued*).

Test No.	Laboratory.	Operator.	Weight of Cup, g.	Capacity of Cup, cc.	Method No. 1.		Method No. 2.	
					Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[a] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[a] deg. Cent.
18[c]	Bausch & Lomb Co............	H.	97.8	100	1.0	49.1	1.2	36.1
19			97.8	100	1.0	44.1	1.1	37.1
20			97.8	100	1.2	45.1	...	....
21			97.8	100	1.0	47.3	...	....
22		Kch.	97.8	100	1.0	46.1	1.0	36.1
23			97.8	100	1.0	48.1	...	....
24			97.8	100	1.3	46.1	...	....
25			97.8	100	1.1	48.2	...	....
26		Kb.	97.8	100	0.9	49.3	1.0	36.2
27			97.8	100	1.0	48.3	...	....
28	Berry Bros.........	E. E. F.	95.4	67	0.7	40.5	0.6	38.8
29	Chemical Service Lab.............	R.	92.6	72	1.0	36.6	1.0	35.6
30	Debevoise Co....	D. W. E.	75	80	1.3	42.0	0.7	39.0
31			75	80	1.2	44.0	1.4	37.0
32			75	80	1.1	42.0	1.1	37.0
33	General Electric Co............	H. M. L.	74.2	84	1.0	39.5	1.0	39.0
34			74.2	84	1.0	39.0	1.0	39.0
35			74.2	84	1.0	38.9	1.0	38.9
36			74.2	84	1.0	38.9	1.0	38.9
37[b]	General Petroleum Co.......	D.B.W.A.	75.6	82	0.7	43.3	1.0	38.4
38			75.6	82	1.2	41.2	0.8	39.3
39[b]	Gulf Refining Co.	J. W. H.[b]	84.8	76	1.0	40.3	0.9	37.9
40			84.8	76	0.9	40.8	1.1	37.8
41		J. E. B.	84.8	76	0.9	40.8	0.9	37.9
42			84.8	76	...	40.3	1.2	38.3
43	George Washington University	J. M. S.	81.2	82	1.1	42.7	0.8	39.2
44			81.2	82	1.0	42.2	1.0	38.2
45		P. B. S.	81.2	82	0.9	43.0	1.0	40.2
46			81.2	82	0.8	41.2	1.5	39.2
47		J. N. T.	81.2	82	1.3	43.2	1.0	39.2
48			81.2	82	1.0	40.2	1.1	38.2
49	John Lucas & Co., Inc.......	H. A. R.	108	67	0.8	42.2	...	....
50			108	67	0.9	42.2	...	....
51			108	67	0.9	42.7	...	....
52		C. A. H.	108	67	1.1	41.2	0.6	40.2
53	N. Y., N. H. & H. R. R. Co...	B. D. J.	94	83	0.8	41.4	0.9	36.5
54			94	83	0.8	40.6	...	....
55		H. E. B.	94	83	1.0	40.4	1.1	37.4
56			94	83	1.1	40.4	...	....
57[b]	Patton Paint Co..	B. L. S.[b]	72	85	0.8	40.7	1.0	36.7
58			72	85	0.9	40.7	0.9	36.7
59			72	85	1.0	40.7	1.2	35.7
60			72	85	0.9	40.7	1.2	36.7

[a] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

[b] The specified thermometer was not used, but the thermometer described by operator appears to be satisfactory.

[c] It was stated that the size of the glass cup was such that the specified 59 cc. of oil did not properly cover the thermometer bulb, when the latter was placed according to directions. The thermometer was lowered another ⅓ in., which brought the bottom of the thermometer almost in contact with the bottom of the cup.

TABLE I.—RESULTS OF TESTS WITH TAGLIABUE OPEN TESTER (*Continued*).

Test No.	Laboratory.	Operator.	Weight of Cup, g.	Capacity of Cup, cc.	Method No. 1.		Method No. 2.	
					Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[a] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[a] deg. Cent.
61	Pratt & Lambert, Inc.	C. J. B.	84	78	0.5	45.7	0.8	40.1
62			84	78	0.5	45.4	0.7	41.9
63			84	78	...	....	0.8	40.4
64			84	78	...	....	0.8	41.8
65		R. W. L.	84	78	0.9	45.6	0.9	41.7
66	Standard Testing Lab.	H. W. M.	98	73	1.2	39.9	1.2	39.9
67			98	73	1.1	39.6	1.0	38.6
68		A. C. K.	98	73	0.8	39.0	1.1	38.9
69			98	73	1.6	37.6	1.3	38.6
70	Sun Co.	H. M.	89.1	75	1.0	39.6	1.0	37.7
71			89.1	75	1.0	39.6	1.0	37.7
72	Texas Co., Bayonne.	E.	77	00	...	40.8	...	37.8
73		Stz.	77	00	...	40.8	...	36.8
74		W.	77	00	...	41.8	...	37.8
75		Em.	77	00	...	40.8	...	36.8
76		Sck.	77	00	...	40.8	...	36.8
77		M.	77	00	...	41.3	...	36.8
78	Texas Co., Lockport.	M. C. P.	76.5	80	0.9	41.0	1.0	36.0
79			76.5	80	0.8	41.0	0.9	36.0
80			76.5	80	0.9	41.0	1.0	37.0
81			76.5	80	...	....	1.0	37.0
82		R. B.	76.5	80	1.1	42.0	1.0	37.0
83			76.5	80	1.0	42.0	0.9	36.0
84	Texas Co., Port Arthur.	D.	99	70	0.9	40.0	0.9	39.0
85		K.	99	70	0.9	40.0	...	39.0
86	Thibaut & Walker Co.	F. A. B.	98	69	1.3	39.0	1.1	38.0
87			98	69	0.8	40.0	1.0	38.0
88			98	69	1.0	41.0	0.9	37.0
89	United Gas Improvement Co.	S.	79	80	0.9	37.7	0.9	37.5
90			79	80	1.1	38.7	0.9	38.0
91			79	80	0.9	38.7	0.8	37.5
92		B.	79	80	1.0	38.7	1.0	37.7
93			79	80	1.0	38.7	1.0	37.7
94			79	80	...	....	1.0	37.7
95	Underwriters Lab	W. K. M.	76.3	80	0.7	40.4	1.4	37.4
96		H. J. M.	76.3	80	1.0	42.4	0.9	36.5
97	University of Wisconsin.	C. A. M.	86.2	77	0.9	39.7	0.9	37.7
98			86.2	77	0.9	40.7	1.0	37.7
99			86.2	77	0.9	39.7	1.1	37.7
100			86.2	77	0.8	39.7	...	....
101	U.S. Gutta Percha Paint Co.	W. W. R.	75.7	80	0.8	40.5	0.6	40.0
102			75.7	80	0.9	40.0	0.9	39.5
103[b]	Vacuum Oil Co.	H. J. H.	97.5	100	0.9	50.3	1.0	36.3
104			97.5	100	1.1	50.3	1.4	37.3
105			97.5	100	1.0	47.3	...	....
106		D. F. R.	97.5	100	1.2	43.3	1.5	36.3
107			97.5	100	1.3	50.3	1.5	36.3
108		L. R. A.	97.5	100	1.4	44.3	1.2	36.3
109	Westinghouse, Church, Kerr & Co.	C. M. C.	77	81	1.3	40.1	1.1	36.8
110			77	81	0.9	40.1	0.7	38.3
111			77	81	1.2	41.8	...	....
112			77	81	0.7	41.3	...	....

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[a] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

[b] Owing to the capacity of the oil cup, it was stated that in following directions, part of the tests were made with one-half of the thermometer bulb exposed.

AVERAGE { 108 tests Method No. 1, deg. Cent. 42.0
94 " " No. 2, " " 37.9

TABLE II.—SUMMARY OF RESULTS OF TESTS WITH TAGLIABUE OPEN TESTER.

Laboratory.	Method No. 1 (Sweep Method).			Method No. 2 (Dip Method).		
	Test No. Eliminated from Laboratory Average.	Difference between Lowest and Highest Reading, deg. Cent.	Laboratory Average, deg. Cent.	Test No. Eliminated from Laboratory Average.	Difference between Lowest and Highest Reading, deg. Cent.	Laboratory Average, deg. Cent.
[1]Atlantic Refining Co	1	...	....	1	...	....
[1]C. V. Bacon	..	1.9	43.4	..	1.0	37.7
[1]Barber Asphalt Paving Co	11	1.0	41.1	..	2.2	37.0
[1]Barrett Co	13–17, inc.	...	....	13	1.0	38.7
Bausch & Lomb Co	18–21, inc.	3.2	47.7	..	1.0	36.4
[1]Berry Bros	28	...	....	28	...	....
Chemical Service Lab	29	...	....	29	...	....
[1]Debevoise Co	..	2.0	42.7	..	2.0	37.7
General Electric Co	..	0.6	39.1	..	0.1	39.0
General Petroleum Co	..	2.0	42.3	..	0.9	38.9
Gulf Refining Co	..	0.5	40.6	..	0.5	38.0
George Washington University	..	3.0	42.1	..	2.0	39.0
[1]John Lucas & Co., Inc	..	1.5	42.1	52	...	....
N. Y., N. H. & H. R. R. Co	..	1.0	40.7	..	0.9	37.0
Patton Paint Co	..	0.0	40.7	..	1.0	36.5
[1]Pratt & Lambert, Inc	..	0.3	45.6	..	1.8	41.2
Standard Testing Lab	..	2.3	39.0	..	1.3	39.0
[1]Sun Co	..	0.0	39.6	..	0.0	37.7
[1]Texas Co., Bayonne	..	1.0	41.1	..	1.0	37.1
[1]Texas Co., Lockport	..	1.0	41.8	..	1.0	36.5
[1]Texas Co., Port Arthur	..	0.0	40.0	..	0.0	39.0
Thibaut & Walker Co	..	2.0	40.0	..	1.0	37.7
United Gas Improvement Co	..	1.0	38.5	..	0.5	37.7
[1]Underwriters Lab	..	2.0	41.4	..	0.9	37.0
Unversity of Wisconsin	..	1.0	40.0	..	0.0	37.7
U. S. Gutta Percha Paint Co	..	0.5	40.3	..	0.5	39.8
Vacuum Oil Co	103–108, inc.	...	....	..	1.0	36.5
[1]Westinghouse, Church, Kerr & Co	..	1.7	40.8	..	1.5	37.6

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[1] Laboratory of sub-committee member.

	METHOD No. 1.	METHOD No. 2.
Lowest laboratory average, deg. Cent	38.5	36.4
Highest laboratory average, " "	47.7	41.2
Difference, deg. Cent	9.2	4.8
AVERAGE { 23 laboratories, deg. Cent	41.3	....
AVERAGE { 24 " " "	...	37.9

TABLE III.—RESULTS OF TESTS WITH ELLIOT TESTER.

Test No.	Laboratory.	Operator.	Weight of Cup, g.	Capacity of Cup, cc.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point, deg. Cent.
1	Armour Institute of Technology	G. C. W.	189.1	473	1.7	32.5
2			189.1	473	1.0	32.5
3			189.1	473	1.4	32.5
4			189.1	473	0.9	32.5
5			189.1	473	1.0	32.5
6	Atlantic Refining Co.	J. C. H.	154.8	450	1.0	32.5
7	C. V. Bacon	I. P. M.	161	476	1.0	32.5
8			161	476	0.9	32.9
9		C. V. B.	161	476	1.0	32.5
10	Barber Asphalt Paving Co	H. P. H.	160	500	1.0	35.7
11			160	500	0.6	32.8
12[b]		C. L. W.	160	500	0.8	32.6
13			160	500	1.0	31.8
14	Bausch & Lomb Co	K.	178.1	500	1.1	33.1
15			178.1	500	0.8	35.1
16			178.1	500	1.0	35.1
17		H.	178.1	500	1.0	31.6
18			178.1	500	1.0	31.6
19		K.	178.1	500	0.9	31.2
20	Berry Bros	E. E. F.	204	347	0.8	32.6
21			204	347	0.4	32.6
22			204	347	0.7	32.6
23	General Electric Co	H. M. L.	179.8	525	1.0	33.5
24			179.8	525	1.0	33.5
25			179.8	525	1.0	33.4
26			179.8	525	1.0	33.4
27	General Petroleum Co	A.	182.8	515	1.0	29.3
28			182.8	515	1.4	32.4
29[b]			162.4	512	1.0	32.4
30			162.4	512	1.1	33.4
31	George Washington University	J. M. S.	174.5	325	1.0	31.2
32			174.5	325	1.0	31.2
33		P. B S.	174.5	325	0.7	32.2
34		J. N. T.	174.5	325	0.7	32.2
35			174.5	325	1.0	31.2
36	Gulf Refining Co	J. W. H.	166.8	515	0.2	32.3
37			166.8	515	1.0	32.8
38[b]		J. E. B.	166.8	515	0.9	32.8
39			166.8	515	1.2	32.3
40	N. Y., N. H. & H. R. R. Co	B. D. J.	141.6	500	1.1	30.4
41		H. E. B.	141.6	500	1.0	30.4
42	Patton Paint Co	B. S.	192	500	0.6	32.7
43			192	500	0.8	32.7
44[b]			192	500	0.8	32.7
45			192	500	1.0	32.7
46			192	500	1.1	33.7
47	Pratt & Lambert, Inc	C. J. B.	133.6	510	0.9	33.1
48			133.6	510	0.8	32.8
49			133.6	510	0.7	31.5
50		R. W. L.	133.6	510	0.8	32.2
51			133.6	510	0.7	33.2

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[a] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

[b] The specified thermometer was not used but the thermometer described by operator appears to be satisfactory.

TABLE III.—RESULTS OF TESTS WITH ELLIOT TESTER (*Continued*).

Test No.	Laboratory.	Operator.	Weight of Cup, g.	Capacity of Cup, cc.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[a] deg. Cent.
52	Pullman Co	A. M. J.	95.9	450	1.0	31.3
53[c]			95.9	450	1.0	31.3
54		D. J. B.	95.9	450	0.9	32.5
55			95.9	450	1.0	32.5
56			95.9	450	1.0	32.7
57	Rock Island R. R	T. D. S.	163	476	0.2	32.0
58[b c]			163	476	1.0	32.4
59			163	476	1.0	31.6
60			163	476	1.0	32.0
61			163	476	0.9	32.4
62			163	476	...	31.6
63	Sherwin-Williams Co	A. C. M.	176	560	1.4	32.5
64			176	560	0.9	32.5
65			176	560	1.0	32.5
66		W. R. E.	176	560	1.0	31.5
67			176	560	0.9	32.5
68			176	560	1.0	32.5
69	Standard Testing Lab	H. W. M.	181	519	0.9	34.0
70			181	519	1.0	32.6
71		A. C. K.	181	519	0.9	34.0
72			181	519	1.0	33.6
73	Sun Co	H. M.	188.5	510	1.0	31.8
74			188.5	510	1.0	32.8
75			188.5	510	1.1	31.8
76	Texas Co., Lockport	M. C. P.	203	500	1.0	31.0
77			203	500	1.0	31.0
78			203	500	0.9	31.0
79		R. B.	203	500	0.9	32.0
80			203	500	1.0	32.0
81	Texas Co., Port Arthur	D.	183.1	505	1.0	31.0
82		K.	183.1	505	0.9	31.0
83	Texas Co., Bayonne	S.	165.5	300	0.9	31.5
84	United Gas Improvement Co	S.	168	500	1.2	33.5
85			168	500	1.2	34.5
86			168	500	2.1	33.2
87			168	500	1.3	33.0
88		B.	168	500	1.4	33.5
89	Underwriters Lab	W. K. M.	192.1	500	0.8	31.5
90		H. J. M.	192.1	500	1.4	32.5
91[d]	Vacuum Oil Co	H. J. H.	178	322	1.3	33.3
92		L. R. A.	178	322	1.3	33.3
93		D. F. R.	178	322	1.4	32.5
94	Yaryan Naval Stores	D.	138.5	455	1.2	33.5
95			138.5	455	1.2	32.5
96			138.5	455	0.9	32.5
97			138.5	455	0.8	33.0
98		K.	138.5	455	1.5	34.0
99			138.5	455	0.8	33.0
100			138.5	455	0.9	32.0

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[a] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

[b] The specified thermometer was not used, but the thermometer described by operator appears to be satisfactory.

[c] The capacity probably signifies that up to the glass cover and not to top of oil cup.

[d] The capacity probably signifies that of the oil space only and not to top of oil cup.

AVERAGE, 100 tests, deg Cent. 32.5

TABLE IV.—SUMMARY OF RESULTS WITH ELLIOTT TESTER.

Laboratory.	Test No. Eliminated from Laboratory Average.	Difference between Lowest and Highest Reading, deg. Cent.	Laboratory Average, deg. Cent.
Armour Institute of Technology	..	0.0	32.5
[1]Atlantic Refining Co	6	...	....
[1]C. V. Bacon	..	0.4	32.6
[1]Barber Asphalt Paving Co	10	1.0	32.4
Bausch & Lomb Co	14–16, inc.	0.4	31.5
[1]Berry Bros	..	0.0	32.6
General Electric Co	..	0.1	33.5
General Petroleum Co	27	1.0	32.7
George Washington University	..	1.0	31.6
Gulf Refining Co	..	0.5	32.6
N. Y., N. H. & H. R. R. Co	..	0.0	30.4
Patton Paint Co	..	1.0	32.9
[1]Pratt & Lambert, Inc.	..	1.6	32.6
[1]Pullman Co	..	1.4	32.1
Rock Island R. R	..	0.8	32.0
Sherwin-Williams Co	..	1.0	32.3
Standard Testing Lab	..	1.4	33.5
[1]Sun Co	..	1.0	32.1
Texas Co., Lockport	..	1.0	31.4
[1]Texas Co., Port Arthur	..	0.0	31.0
[1]Texas Co., Bayonne	..	...	....
United Gas Improvement Co	..	1.5	33.5
[1]Underwriters Lab	..	1.0	32.0
Vacuum Oil Co	..	1.2	33.0
Yaryan Naval Stores	..	2.0	33.0

[1] Laboratory of sub-committee member.

Lowest laboratory average, deg. Cent	31.0
Highest " " " "	33.5
Difference, deg. Cent	.5
AVERAGE, 23 laboratories, deg. Cent	32.

TABLE V.—RESULTS OF TESTS WITH ABEL-PENSKY TESTER.

Test No.	Laboratory.	Operator.	Method No. I (Official Method).		Method No. II (Sub-Committee Method).	
			Rise in Temperature per Minute during Test, deg. Cent.	Flash Point, deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point, deg. Cent.
1	Atlantic Refining Co	J. C. H.	...	34.0	1.0	34.0
2	Barber Asphalt Paving Co	H. P. H.	1.2	33.6	1.0	34.2
3			1.5	33.8	1.0	33.8
4		C. L. W.	1.2	33.6	0.9	33.6
5			1.2	32.8	1.0	33.4
6	Chemical Service ab	R.	1.2	34.6	0.8	33.6
7			1.1	34.1	0.8	33.6
8			0.9	33.6	0.9	33.6
9	General Petroleum Co	A.	1.2	35.2	0.9	34.8
10			1.2	35.2	...	....
11	George Washington University	J. M. S.	...	....	0.4	33.7
12			...	....	0.5	33.2
13		P. B. S.	...	....	0.5	33.2
14			...	....	0.7	33.2
15		J. N. T.	...	....	0.5	33.7
16			...	....	0.4	33.2
17	Gulf Refining Co	J. W. H.	1.1	34.3	0.7	34.4
18			1.0	34.3	1.0	34.3
19		J. E. B.	1.5	34.8	1.0	34.4
20			1.4	34.3	1.0	34.8
21	Lowe Bros	H. C. M.	2.0	36.1	0.9	36.0
22			2.1	35.6	0.8	36.6
23			1.8	35.6	...	....
24	John Lucas & Co,. Inc	C. A. H.	...	....	0.5	35.7
25			...	....	0.5	35.2
26	National Cash Register Co	R.	1.2	34.7	0.6	34.2
27			1.4	34.7	0.7	34.2
28			1.3	34.1	0.8	34.5
29			1.4	34.5	0.7	34.0
30	Standard Testing Lab	H. W. M.	1.3	33.5	1.0	34.4
31			2.0	33.6	1.0	33.0
32		A. C. K.	2.0	33.5	0.7	33.9
33			2.3	33.1	1.0	34.0
34	Sun Co	H. M.	1.8	34.4	1.0	34.3
35			1.8	34.4	1.0	34.3
36	Underwriters Lab	W. K. M.	1.7	35.5	1.6	35.0
37			...	....	1.0	34.5
38		H. J. M.	1.8	35.0	1.0	34.5
39		G. B. J.	1.7	34.5	...	....
40	U. S. Gutta Percha Paint Co	W. W. R.	0.9	35.0	0.8	35.5
41			1.0	34.5	0.9	35.0
42	Texas Co., Bayonne	S.	2.0	34.4	0.8	34.9

AVERAGE { 33 tests Method No. I, deg. Cent. 34.4
39 " " No. II, " " 34.3

TABLE VI.—SUMMARY OF RESULTS OF TESTS WITH ABEL-PENSKY TESTER.

Laboratory.	Method No. I (Official Method).			Method No. II (Sub-Committee Method).		
	Test No. Eliminated from Laboratory Average.	Difference between Lowest and Highest Reading, deg. Cent.	Laboratory Average, deg. Cent.	Test No. Eliminated from Laboratory Average.	Difference between Lowest and Highest Reading, deg. Cent.	Laboratory Average, deg. Cent.
[1]Atlantic Refining Co.	1	...	....	1	...	....
[1]Barber Asphalt Paving Co.	..	1.0	33.5	..	1.0	33.8
Chemical Service Lab.	..	1.0	34.1	..	0.0	33.6
General Petroleum Co.	..	0.0	35.2	9	...	....
George Washington University	..	...	....	..	0.5	33.4
Gulf Refining Co.	..	0.5	34.4	..	0.5	34.5
Lowe Bros.	..	0.5	35.8	..	0.6	36.3
[1]John Lucas & Co., Inc.	..	...	....	..	0.5	35.5
National Cash Register Co.	..	0.6	34.5	..	0.5	34.2
Standard Testing Lab.	..	0.5	33.4	..	1.4	33.8
[1]Sun Co.	..	0.0	34.4	..	0.0	34.3
[1]Underwriters Lab.	..	1.0	35.0	..	0.5	34.7
U. S. Gutta Percha Paint Co.	..	0.5	34.8	..	0.5	35.3
[1]Texas Co., Bayonne	..	...	....	..	...	....

	METHOD No. I.	METHOD No. II.
Lowest laboratory average, deg. Cent.	33.4	33.4
Highest laboratory average, " "	35.8	36.3
Difference, deg. Cent.	2.4	2.9
AVERAGE { 10 laboratories, deg. Cent.	34.5	....
AVERAGE { 11 " " "	....	34.5

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[1] Laboratory of sub-committee member.

TABLE VII.—RESULTS OF TESTS WITH ABEL TESTER.

Test No.	Laboratory.	Operator.	Method No. I (Official Method).		Method No. II (Sub-Committee Method).	
			Rise in Temperature per Minute during Test, deg. Cent.	Flash Point, deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point, deg. Cent.
1	Atlantic Refining Co	J. C. H.	...	32.5	1.0	32.6
2	Armour Institute of Technology	G. C. W.	2.0	31.1	0.7	33.6
3			1.7	33.6	0.8	33.1
4			2.0	33.6	0.7	33.1
5			1.5	33.1	0.7	33.1
6			1.8	34.1	...	....
7			1.9	33.6	...	....
8	Bausch & Lomb Co	K.	0.5	33.1	2.0	31.2
9			0.9	31.1	...	....
10			1.0	32.1	...	....
11			1.0	32.1	...	....
12		H.	1.0	32.1	2.0	31.2
13			1.0	32.1	...	....
14		K.	0.8	31.1	...	....
15	Gulf Refining Co	J. W. H.	1.5	32.3	0.7	32.8
16			0.8	32.3	0.9	32.3
17		J. E. B.	1.2	32.3	1.0	32.3
18			1.4	32.3	1.0	32.8
19	Texas Co., Port Arthur	D.	2.0	29.5	1.0	31.0
20		K.	2.4	29.5	0.6	31.0
21	United Gas Improvement Co	S.	1.6	34.3	0.4	32.1
22			1.7	33.8	0.4	32.6
23			2.0	33.6	0.4	32.8
24			1.6	33.1	0.4	32.7
25			1.6	34.0	0.4	32.9
26		B.	1.7	34.0	0.9	33.6
27			1.7	34.0	0.8	33.3
28			1.7	34.0	0.9	33.8
29			0.6	34.0	1.0	33.6
30			1.7	33.8	0.9	33.4
31	Vacuum Oil Co	H. J. H.	1.0	32.5	0.7	32.2
32			...	....	0.9	33.2
33		D. F. R.	1.0	32.5	0.8	32.7
34		L. R. A.	0.8	32.0	0.9	33.7
35	Yaryan Naval Stores	D.	1.8	32.2	0.8	32.2
36			1.7	32.2	0.9	32.2
37			1.7	32.2	0.8	32.2
38			1.5	32.2	0.8	32.2
39		K.	2.0	31.7	0.9	32.8
40			2.0	31.7	0.9	32.8

AVERAGE {39 tests Method No. I, deg. Cent.................................. 32.6
AVERAGE {33 " " No. II, " " 32.6

TABLE VIII.—SUMMARY OF RESULTS OF TESTS WITH ABEL TESTER.

Laboratory.	Method No. I (Official Method).			Method No. II (Sub-Committee Method).		
	Test No. Eliminated from Laboratory Average.	Difference between Lowest and Highest Reading, deg. Cent.	Laboratory Average, deg. Cent.	Test No. Eliminated from Laboratory Average.	Difference between Lowest and Highest Reading, deg. Cent.	Laboratory Average, deg. Cent.
Atlantic Refining Co.	1	...	....	1	...	....
Armour Institute of Technology	2	1.0	33.6	..	0.5	33.2
Bausch & Lomb Co.	..	2.0	32.0	..	0.0	31.2
Gulf Refining Co.	..	0.0	32.3	..	0.5	32.6
[1]Texas Co., Port Arthur	..	0.0	29.5	..	0.0	31.0
United Gas Improvement Co.	..	1.2	33.9	..	1.7	33.1
Vacuum Oil Co.	..	0.5	32.3	..	0.5	33.5
Yaryan Naval Stores	..	0.5	32.0	..	0.6	32.4

[1] Laboratory of sub-committee member.

	METHOD No. I.	METHOD No. II.
Lowest laboratory average, deg. Cent.	29.5	31.0
Highest laboratory average, " "	33.9	33.5
Difference, deg. Cent.	4.4	2.5
AVERAGE, 7 laboratories, deg. Cent.	32.2	32.4

In obtaining the laboratory average certain tests were eliminated for the reasons noted in Table IX.

TABLE IX.—REASONS FOR ELIMINATING CERTAIN TESTS FROM COMPUTATION OF AVERAGES.

TAGLIABUE OPEN CUP TESTER.

Test No.	Method No.	Reasons.
	1, 2	Only one test reported under each method.
11	1	Tests 11 and 12, method No. 1, by one operator were not acceptable checks, but as No. 12 agreed with check tests of another operator in same laboratory, one No. 11 was eliminated.
13 to 17, inc.	1	No operator obtained acceptable check results, so all tests under method No. 1 were eliminated.
13	2	Only one test by operator, which test did not check with others of same laboratory.
18 to 21, inc.	1	Not a sufficient check.
28	1, 2	Only one test reported under each method.
29	1, 2	Only one test reported under each method.
52	2	Only one test reported under method No. 2.
103 to 108, inc.	1	No operator obtained acceptable check results, so all tests under method No. 1 were eliminated.
		ELLIOT TESTER.
6	..	Only one test reported.
10	..	Higher than all other tests made at same laboratory.
14, 15, 16	..	Higher than other check tests made in same laboratory, and also higher than any other laboratory.
27	..	Lower than other check tests made in same laboratory, and also lower than any other laboratory.
		ABEL-PENSKY TESTER.
1	I, II	Only one test reported.
9	II	Only one test reported.
		ABEL TESTER.
1	I, II	Only one test reported under each method.
2	II	Lower than other check tests by same operator.

APPENDIX II.

TEST OF 1915 SERIES.

The following directions for the 1915 series of tests were sent to every member of the sub-committee.

For the new series of flash-point tests to be made with Tagliabue Open tester, Abel-Pensky Closed tester and U. S. Bureau of Mines Model tester, three samples of paint thinners have been forwarded to you as follows:

Sample No. 1.—One-gallon sample marked petroleum spirits No. 1 forwarded from Texas Co. by Mr. K. G. Mackenzie.

Sample No. 2.—One-quart sample of coal-tar solvent naphtha marked sample thinner No. 2 forwarded from the Barrett Co., by Mr. J. M. Weiss

Sample No. 3.—One-half-gallon sample marked petroleum thinner No. 3 forwarded from Barber Asphalt Paving Co. by Mr. C. N. Forrest. Keep samples tightly corked and in a cool place.

As these tests are to be made only in the laboratories of members of the sub-committee, and as it is desirable to have a large number of tests made in order that averages may be dependable, it is urged that each laboratory make not less than three and preferably four tests on each tester by each method outlined in accompanying instructions. Each operator should submit at least two tests of each method and each cup.

Tagliabue Open Tester.—Owing to the wide variation in the weight and capacity of the glass cups reported as used in making the first series of flash-point tests, there was forwarded to you recently by express a standardized glass cup and a standardized metal cup for use in making new tests. Also an official certified thermometer which is loaned you by the sub-committee for these tests. The flame bead and the metal blow-pipe tube with wheel guard, were forwarded you at the time of the previous tests. Three tests each by methods Nos. 1 and 2 with standardized glass cup and standardized metal cup are requested, making 12 tests in all. More than this number of tests will be accepted. Detailed directions covering the methods of operation are enclosed.

Table I gives the calibration of the glass and metal oil cups used in the Tagliabue Open tester in flash-point tests. Each type of cup was uniform in shape, thickness, and general appearance. The testing for capacity was by the use of a hook gage, the cups being filled to within $\frac{1}{4}$ in. of the top, using water at a temperature of 20° C.

Abel-Pensky Closed Tester.—To those members of the sub-committee who have the Abel-Pensky tester, and who have agreed to make tests also on Tagliabue type of cup, there will be included directions for tests of the three liquids.

Bureau of Mines Model Tester.—As this tester was not available last spring, when the first series of flash-point tests were made, it was impossible at that time to include it in the investigation. Through the courtesy of the makers, the Taylor Instrument Co., four of the instruments will be loaned to the members of the sub-committee. These instruments will be passed from one member to another as rapidly as possible, so that all who desire can make tests. Detailed directions covering the method of operation are enclosed.

General Information.—It is preferable that barometer readings be made in the laboratory at the time of making tests. If this is not available, the nearest weather bureau office can give you the information, but be sure and obtain same for the time of day that tests were made. For your information, 10 mm. difference in barometer makes approximately 0.°3 C. difference in flash point, and the barometer may change much more than this during the day. On report blanks should be stated whether barometer in laboratory or weather bureau was used.

TABLE I.—CALIBRATION OF CUPS USED FOR TAGLIABUE OPEN TESTER IN 1915 SERIES OF TESTS.

Cup No.	Glass Cups.		Brass Cups.	
	Weight, g.	Capacity, cc.	Weight, g.	Capacity, cc.
1	73.00	70.0	50.85	60.4
2	74.64	69.0	49.71	60.5
3	71.18	70.9	49.98	60.6
4	70.96	70.4	49.10	60.5
5	73.76	69.1	50.89	60.9
6	74.04	69.6	49.15	60.4
7	70.66	70.9	50.40	60.8
8	71.67	60.1	50.42	61.8
9	71.77	70.3	51.03	61.3
10	72.23	69.4	50.07	61.1
11	72.77	70.1	50.58	60.8
12	72.28	70.2	50.55	61.0
13	71.48	70.1	49.62	60.2
14	71.76	70.5	49.65	60.4
15	73.44	69.4	50.06	60.8
16	71.10	70.5	51.53	60.9
17	70.93	69.9	50.45	61.4
Maximum	74.64	70.9	50.85	61.8
Minimum	70.66	69.0	49.10	60.2
Difference	3.98	1.9	1.75	1.6

Methods of operation enclosed should be strictly followed, and only tests made strictly in accord with these directions should be reported.

DIRECTIONS FOR OPERATION OF TAGLIABUE OPEN TESTER.

General Directions.—Test shall be made in a room partially darkened.

The cap shall be protected by a surrounding screen, 16 in. square, 30 in. high, open at top and front, and painted black inside. Drafts caused by the breath of the operator shall be carefully avoided.

A fresh sample shall be used for each test.

The instrument must stand level.

Take reading of barometer at time of test.

Preparation of Water Bath.—Fill the metal bath with water at the temperatures given below for the respective samples, so that when the cup is in place, the water in bath will come to the rim of the cup. The water in the bath at beginning is intended to be approximately 11° C. (20° F.) below the flash point, or as follows:

Sample No. 1—Water at temperature of 30° C. (86° F.).
Sample No. 2— " " " " 15.°5 C. (60° F.).
Sample No. 3— " " " " 40° C. (104° F.).

Preparation of Sample.—Suspend the official certified thermometer in the center of the cup with the top of the bulb of same ½ in. below the upper level edge of the glass or metal cup. Bring the sample to be tested to the following temperature (the sample at the beginning is intended to be approximately 17° C. (30° F.) below the flash point by open cup):

Sample No. 1—Sample at temperature of 25° C. (76° F.).
Sample No. 2— " " " " 10° C. (50° F.).
Sample No. 3— " " " " 35° C. (95° F.).

In a 100-cc. graduate, measure out 70 cc. of the sample when using glass cup, and 61 cc. of the sample when using metal cup and pour into the cup. See that there is no oil on the outside of the cup or its upper edge, using a filter paper to clean the cup. Remove air bubbles, if any, from the surface of the oil.

NOTE.—The horizontal flashing-taper guide wire (as specified in the directions of the manufacturer) is *not* to be used in these tests.

Application of Heat to Oil Cup.—Heat the bath with an alcohol, gas or other flame, so adjusted that the temperature of the sample will not be raised faster or much slower than 1° C. (1.°8 F.) per minute without removing the flame.

Description of Test Flame.—The test flame shall be spherical in form, and shall have a diameter equal in size to the bead furnished by the subcommittee, which may be attached to the cover of the water bath. This flame is produced by passing gas through a straight, thin-metal tube. This tube has a wheel-guard for use in dip method. This tube has been furnished you by the sub-committee. A gas flame as specified is necessary, as a wax, straw, or lard oil, etc., taper will give unreliable results.

Initial Test.—When the sample under test reaches a temperature given below for the respective samples (the initial test on a sample is intended to be approximately 11° C. (20° F.) below the flash point), the first test shall be made, and tests shall be made thereafter at each rise of 1° C. (1.°8 F.) until the flash point is reached.

Sample No. 1—First test at temperature 30° C. (86° F.).
Sample No. 2— " " " " 15° C. (60° F.).
Sample No. 3— " " " " 40° C. (104° F.).

Method of Applying Test Flame.—Both of the following two methods are to be used and reported on. (Remove horizontal flashing-taper guide wire.)

1. *Sweep Method.*—Holding the burner tube in a horizontal position the flame is passed in a straight line continuously across the center of the cup, with the tube touching the edge of the cup. The time for one sweep from edge to edge of the cup to be gaged to one second. The temperature at which a flame first appears anywhere on the surface of the oils shall be considered the flash point.

2. *Dip Method.*—The burner tube should have wheel-guard in place, which is such that when held in vertical position resting on a level surface, the end of tube and the wheel guard should both touch this surface.

Holding the burner tube in a vertical position with the flame 3 in. above the surface of the sample, the tube is lowered until the wheel guard rests on the edge of the cup. This brings the flame within ⅛ in. of the surface of the sample. Hold the flame at surface of the oil not to exceed one second and withdraw. This operation is repeated at two opposite points around the circumference of the cup. The temperature at which a blue flame jumps from the taper to the surface of the oil is the flash point, no matter how small this may be. (This has to be watched for very carefully because very often there is a blue halo around the flame which does not jump from flame to surface of the liquid.)

Barometer.—Take reading of the barometer at time of test. If there is no barometer in the laboratory obtain reading from nearest weather bureau which will be able to give a report at hour of test. The barometer may change markedly during the day.

DIRECTIONS FOR OPERATION OF ABEL-PENSKY TESTER.

Use method No. I (Official Method) only, as given in directions for 1914 series of tests. (See Appendix I.)

The following are the sub-committee's supplementary notes to the Official Method, as applying to the three samples under test:

Section 3.—Note that this applies only to temperature at which the release pin is first pressed; in other words, the start of test is from 13 to 17° C., depending on barometer reading at time of test. The above temperatures apply only to sample No. 2, which is a low flashing oil. On samples Nos. 1 and 3, tests should be started by directions under Section 4, as these are higher flashing oils.

Section 4.—For samples Nos. 1 and 3, make preliminary tests for flash point (which will vary according to barometer) and start testing at 5 to 7° C. below this flash point as stated in Section 4.

Section 6.—The water in the container should be at the following temperatures:

For Sample No. 1	60 to 63° C.	(140 to 145° F.)
" " No. 2	50 to 52° C.	(122 to 126° F.)
" " No. 3	68 to 71° C.	(155 to 160° F.)

Section 9.—The temperature to which water bath is to be heated is as follows:

For Sample No. 1	65° C.	(149° F.)
" " No. 2	55° C.	(131° F.)
" " No. 3	71° C.	(160° F.)

DIRECTIONS FOR OPERATION OF BUREAU OF MINES MODEL TESTER.

The instrument should be set up so that the surface of the oil cup will be level. It should be protected from drafts and placed where the light is not too bright, as the test flame and the flash are more accurately observed in a dim light. A room temperature of from 18 to 20° C. is desirable.

Fill the water bath with water the temperature of which is at least 10° C. below the approximate flash point of the sample being tested. Fill the bath through the funnel opening until water runs out of the overflow opening.

The sample of oil to be tested should be thoroughly mixed and free from any traces of water or foreign matter. The temperature of the sample should be at least 10° C. below the approximate flash point.

The oil cup should be clean and dry. The cup should be placed in the bath, and the overflow cover ring and the cover with the thermometer in place put on. The cup should be filled through the door in the cover.

The oil should be poured in until the lower end of the pointer on the under side of the cover just touches the surface of the oil. Care must be taken in filling the cup not to splash oil up onto the sides of the cup or to form froth on the surface of the oil. All bubbles on the surface should be broken by pricking with a heated wire.

After the cup is filled, close the door and light the test flame, adjusting the size of same to the size of the ivory bead on the cover. When the gas test flame is used, arrange the pilot light so it will relight the test flame if it is blown out.

Light the burner under the water bath and adjust same so that the temperature of the oil will rise at the rate of 1° C. per minute.

Stir the oil constantly and regularly at approximately one revolution per second. When the temperature of the oil is 5° C. below the approximate flash point, expose the test flame to the vapor for one second, which is done mechanically by pressing the insulated knob marked "press." The clock should be wound before each opening of the cover, by turning the knob marked "wind" until it comes to a stop.

Continue stirring and exposing the test flame at each 0°.5 C. rise in temperature until the flash occurs.

The temperature, as indicated by the oil cup thermometer, at which a slight explosion occurs when the test flame is exposed, is the indicated flash point. The true flash point is obtained by correcting the indicated flash point for barometric pressure by using the tables supplied herewith. The standard normal barometric pressure is considered to be 760 mm.

Do not correct indicated flash point for barometric pressure, as this will be done by the sub-committee section having charge of tabulation of all reports.

RESULTS OF TESTS.

Tables II, III and IV give the results of tests of the 1915 series of flash-point determinations.

TABLE II.—RESULTS OF TESTS.

SAMPLE NO. 1.

Test No.	Operator.	Type of Tester.											
		Tagliabue Open.								Abel-Pensky.		Bureau of Mines.	
		Method No. 1.				Method No. 2.							
		Glass Cup.		Metal Cup.		Glass Cup.		Metal Cup.					
		Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.
1	Forrest	...	44.2	...	46.2	...	39.2	...	38.2	...	34.2	...	35.0
2		...	45.2	...	43.2	...	38.2	...	38.2	...	34.7	...	34.6
3		...	46.2	...	44.2	...	39.2	...	37.2	...	....	...	....
4	Bragg	1.0	37.5	0.8	43.4	1.3	38.5	1.0	37.4	...	....	...	....
5		0.9	38.5	1.0	40.4	...	....	1.0	36.4	...	....	...	....
6		...	....	1.0	39.4	...	....	...	....	...	....	...	....
7	Weiss	1.0	42.5	1.0	42.5	1.0	41.5	1.0	40.5	...	....	1.0	34.2
8		1.0	42.5	1.2	43.5	1.0	39.5	1.0	40.5	...	....	0.9	33.7
9		1.0	40.5	1.0	44.5	1.0	40.5	1.0	39.5	...	....	0.9	33.2
10	Nuckolls	1.2	41.2	1.0	42.2	1.2	36.2	1.0	37.2	1.2	33.3	1.1	33.9
11		0.9	41.2	1.3	44.2	...	36.2	1.0	37.2	1.5	33.3	1.2	33.4
12		1.0	42.2	1.2	42.2	...	37.2	1.0	36.2	1.5	33.3	1.0	33.4
13	Maitland	1.2	41.2	2.2	43.2	0.8	37.1	1.2	36.2	1.0	34.8	0.8	33.5
14		1.0	42.0	0.9	42.2	0.8	38.1	1.2	35.2	1.2	34.8	1.0	33.5
15		0.9	42.0	0.9	40.6	1.0	37.2	...	....	...	....	...	....
16		0.9	43.1	1.0	39.7	0.9	36.1	...	....	...	....	...	....
17		1.0	42.1	1.1	40.7	1.0	36.1	...	....	...	....	...	....
18		1.1	43.1	...	....	...	....	...	....	...	....	...	....
19		1.0	43.1	...	....	...	....	...	....	...	....	...	....
20	Nemzek	0.8	40.3	1.0	40.8	1.2	38.9	0.9	39.5	...	....	0.8	35.5
21		1.3	40.8	1.2	40.3	0.8	39.4	1.1	39.5	...	....	0.6	35.5
22		1.0	40.3	0.9	40.3	0.9	39.4	1.0	39.5	...	....	0.8	35.5
23		1.0	40.4	...	....	1.0	39.4	...	....	...	....	...	....
24		0.9	40.4	0.9	41.7	0.9	40.7	0.8	39.6	...	....	0.9	34.7
25	Lindsay	0.8	44.7	1.0	41.6	0.8	40.6	0.9	39.6	...	....	...	34.2
26		0.7	44.7	...	....	...	....	...	....	...	....	...	....
27	Veitch	1.4	40.8	1.8	40.8	1.1	37.8	0.5	37.8	1.6	35.4	0.9	34.4
28		1.0	39.8	1.3	38.8	1.4	36.8	1.0	36.8	1.3	35.4	0.7	33.9
29		1.1	40.8	1.1	39.8	1.0	38.8	1.0	36.8	...	....	...	....
30	Chapman	1.1	38.9	1.0	41.0	1.2	38.4	0.9	38.5	2.5	33.8	1.5	33.3
31		1.0	39.9	1.1	40.0	0.9	37.9	1.0	38.0	1.5	34.3	0.6	32.3
32		0.9	40.0	0.9	39.0	1.1	37.9	1.1	38.0	1.3	34.3	1.0	33.3
33		0.8	36.8	...	....	0.9	37.8	...	....	1.5	34.3	...	....
34		1.0	37.8	...	....	0.8	38.8	...	....	...	....	...	....
35		0.9	38.8	...	....	0.9	39.8	...	....	...	....	...	....
36	Edgerly	0.8	39.3	...	....	...	....	...	....	...	....	0.9	34.0
37		1.1	42.3	...	....	...	....	...	....	...	....	0.8	33.5
38		1.0	40.3	...	....	...	....	...	....	...	....	1.0	33.0
39	Johnson	0.8	39.5	0.8	39.4	0.8	38.2	0.7	38.4	...	....	0.8	34.7
40	Mackenzie	1.0	40.6	0.9	40.6	0.9	36.6	0.9	36.6	1.5	35.1	1.3	35.1
41		0.9	40.6	0.9	40.6	1.0	36.6	0.9	36.6	0.8	35.1	0.9	35.6
42	Bacon	1.0	43.1	0.9	41.6	...	....	...	....	...	....	1.0	34.3
43		...	....	...	....	...	....	...	....	...	....	1.0	34.8
44		...	....	...	....	...	....	...	....	...	....	1.0	35.3
45		...	....	...	....	...	....	...	....	...	....	1.0	34.3
46		...	....	...	....	...	....	...	....	...	....	0.8	34.8
47		...	....	...	....	...	....	...	....	...	....	0.	34.8
	Average		**41.2**		**41.5**		**38.3**		**38.0**		**34.4**		**34.2**

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[1] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

TABLE II.—RESULTS OF TESTS (*Continued*).

SAMPLE NO. 2.

Test No.	Operator.	Type of Tester.											
		Tagliabue Open.								Abel-Pensky.		Bureau of Mines.	
		Method No. 1.				Method No. 2.							
		Glass Cup.		Metal Cup.		Glass Cup.		Metal Cup.					
		Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.
1	Forrest	...	29.1	...	29.2	...	26.1	...	25.1	...	22.2	...	22.2
2		...	30.1	...	30.2	...	25.1	...	24.1	...	22.2	...	22.7
3		...	31.1	...	31.2	...	24.1	...	24.1	...	....	...	....
4	Bragg	0.8	24.5	0.8	27.4	1.0	23.5	0.9	23.4	...	....	...	....
5		0.6	25.5	1.0	27.4	...	....	...	....	...	....	...	....
6	Weiss	1.1	28.6	1.0	26.5	1.0	23.6	1.0	24.5	...	....	...	20.7
7		1.0	25.6	1.0	25.5	1.2	24.6	1.0	24.5	...	....	0.7	20.7
8		1.0	30.6	1.0	26.5	1.0	26.6	1.0	24.5	...	....	...	....
9		...	....	1.1	27.5	...	....	...	....	...	....	...	....
10	Nuckolls	1.0	27.2	0.9	27.3	1.0	23.3	1.0	22.3	1.7	21.2	...	....
11		1.0	26.2	1.1	26.3	0.8	23.3	1.0	22.3	1.7	21.2	...	....
12		1.0	28.2	0.7	25.3	0.9	22.3	1.1	22.3	1.7	21.2	...	....
13	Maitland	1.1	26.2	0.8	26.9	...	....	...	....	1.8	21.8	1.0	21.0
14		0.9	26.2	1.0	25.9	...	....	...	....	1.8	21.8	0.9	21.1
15		...	....	1.0	26.9	...	....	...	....	...	....	...	....
16	Nemzek	0.9	25.3	1.1	25.3	0.9	24.3	0.9	24.8	...	....	0.9	22.0
17		0.8	25.3	0.9	25.3	1.0	24.3	1.2	24.8	...	....	0.9	22.0
18		0.8	25.3	1.0	25.3	0.9	24.3	1.0	24.8	...	....	0.9	21.5
19		...	....	...	....	...	....	...	....	...	....	1.6	21.5
20	Lindsay	0.9	28.6	1.0	28.6	1.0	25.6	0.8	24.6	...	....	0.8	21.2
21		0.9	28.6	1.0	28.6	0.9	25.6	1.0	24.6	...	....	0.7	21.2
22	Veitch	1.4	25.6	1.0	26.6	1.0	24.6	1.1	23.6	1.7	22.3	0.6	22.3
23		1.2	26.6	1.2	26.6	0.9	25.6	0.8	23.6	1.2	22.3	0.7	21.8
24		1.0	27.6	1.3	27.6	1.1	23.6	1.0	23.6	...	....	...	....
25	Chapman	...	....	...	....	...	....	...	....	1.3	22.8	1.0	21.3
26		...	....	...	....	...	....	...	....	0.9	21.8	0.8	21.3
27		...	....	...	....	...	....	...	....	1.8	22.8	1.1	20.8
28		...	....	...	....	...	....	...	....	1.3	21.8	...	....
29	Edgerly	1.2	25.3	...	....	...	....	...	....	...	....	0.7	21.4
30		1.6	26.3	...	....	...	....	...	....	...	....	1.1	21.9
31		1.2	25.3	...	....	...	....	...	....	...	....	0.8	21.9
32	Johnson	1.0	25.1	0.8	25.9	0.9	24.1	0.9	24.4	...	....	0.8	23.7
33	Mackenzie	1.0	27.6	1.0	27.6	1.0	22.6	1.0	23.6	1.5	22.6	1.3	21.6
34		1.0	27.6	1.0	27.6	1.0	22.6	1.1	23.6	0.8	22.6	0.6	21.6
35	Bacon	1.2	29.6	0.5	28.4	...	....	...	....	...	....	0.5	21.6
36		1.1	29.1	1.2	29.6	...	....	...	....	...	....	0.5	20.6
37		1.0	28.6	...	....	...	....	...	....	...	....	0.5	21.6
38		0.8	29.6	...	....	...	....	...	....	...	....	0.7	21.6
	Average		27.3		27.3		24.3		24.0		22.0		21.6

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[1] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

TABLE II.—RESULTS OF TESTS (*Continued*).

SAMPLE NO. 3.

Test No.	Operator.	Type of Tester.											
		Tagliabue Open.								Abel-Pensky.		Bureau of Mines.	
		Method No. 1.				Method No. 2.							
		Glass Cup.		Metal Cup.		Glass Cup.		Metal Cup.					
		Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.
1	Forrest	...	55.2	...	54.2	...	49.2	...	49.2	...	45.7	...	46.1
2		...	56.2	...	53.2	...	47.2	...	48.2	...	45.2	...	46.6
3		...	55.2	...	55.2	...	49.2	...	49.2	...	....	...	....
4	Bragg	0.7	51.7	0.8	49.4	0.6	48.6	1.0	48.4	...	....	...	....
5		0.6	51.7	1.1	50.4	...	....	...	....	...	....	...	....
6	Weiss	0.9	51.5	1.0	54.6	0.9	49.5	1.0	50.6	...	....	1.0	44.2
7		1.0	52.5	1.0	54.6	1.0	50.5	1.0	50.6	...	....	1.0	44.2
8		1.0	53.5	0.9	56.6	1.0	52.5	1.1	50.6	...	....	...	....
9	Nuckolls	1.0	52.3	1.0	53.2	0.9	46.3	1.0	45.2	1.2	44.2	0.8	45.3
10		1.0	52.3	1.1	54.2	1.0	45.3	1.2	46.2	1.0	44.7	1.0	45.3
11		1.1	52.3	1.1	54.2	1.2	46.3	0.9	46.2	0.9	44.7	0.9	44.8
12	Maitland	1.0	53.3	...	....	...	....	...	....	0.9	45.8	1.0	45.7
13		1.0	52.9	...	....	...	....	...	....	0.8	45.8	0.8	45.7
14	Nemzek	0.9	51.7	1.1	51.7	1.2	49.7	1.2	49.7	...	....	0.9	46.1
15		1.1	51.7	1.0	51.7	0.8	49.7	0.9	49.7	...	....	0.9	46.1
16		1.1	52.2	1.0	51.7	0.9	49.2	1.0	49.7	...	....	0.9	46.1
17	Lindsay	0.8	52.5	0.8	51.7	0.8	49.7	0.8	50.6	...	....	1.0	45.7
18		0.7	52.7	0.9	51.7	0.8	49.7	0.9	50.6	...	....	0.9	45.2
19	Veitch	0.6	55.0	1.7	56.6	0.9	53.0	1.1	49.6	0.7	45.4	0.9	45.4
20		1.2	55.0	1.1	56.6	0.7	53.0	0.9	48.6	0.9	45.4	0.7	45.9
21		0.9	54.0	1.2	55.6	1.1	52.0	0.7	48.6	...	....	...	....
22	Chapman	...	....	...	....	...	....	...	....	1.7	45.3	1.4	44.3
23		...	....	...	....	...	....	...	....	1.4	45.8	1.1	44.8
24		...	....	...	....	...	....	...	....	0.9	44.8	1.0	45.3
25	Edgerly	1.5	49.3	...	....	...	....	...	....	...	....	1.0	45.0
26		1.1	48.3	...	....	...	....	...	....	...	....	1.0	45.0
27		1.3	49.3	...	....	...	....	...	....	...	....	...	....
28	Johnson Mackenzie	1.0	51.0	1.0	51.4	1.0	49.9	1.0	49.9	...	....	1.0	45.7
29		1.0	52.6	1.0	51.6	1.0	46.6	0.9	45.6	0.9	46.6	0.7	46.6
30		1.0	52.6	0.9	51.6	1.0	46.6	1.0	45.6	1.0	46.6	0.9	46.6
31	Bacon	1.1	51.6	...	52.2	...	....	...	....	...	....	0.3	45.3
32		0.8	50.6	0.8	49.6	...	....	...	....	...	....	0.9	45.8
33		0.7	50.6	1.0	50.6	...	....	...	....	...	....	0.6	45.6
34		...	....	1.1	52.7	...	....	...	....	...	....	0.9	44.6
	Average		52.4		53.0		49.2		48.7		45.4		45.5

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[1] Corrected by sub-committee for barometric pressure All flash points are given as of 760 mm. atmospheric pressure.

TABLE III.—SUMMARY OF RESULTS OF TESTS.

SAMPLE NO. 1.

Operator.	Type of Tester																	
	Tagliabue Open.												Abel-Pensky.			Bureau of Mines.		
	Method No. 1.						Method No. 2.											
	Glass Cup.			Metal Cup.			Glass Cup.			Metal Cup.								
	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent	Laboratory Average, deg. Cent.
Forrest......	..	2.0	45.2	1	1.0	43.7	..	1.0	38.9	..	1.0	37.9	..	0.5	34.5	..	0.4	34.8
Bragg.......	..	1.0	38.0	4	1.0	39.9	4	...	....	..	1.0	36.9	..	...	....	..	...	....
Weiss.......	..	2.0	41.8	..	2.0	43.5	..	2.0	40.5	..	1.0	40.2	..	...	....	..	1.0	33.7
Nuckolls....	..	1.0	41.5	..	2.0	42.9	..	1.0	36.5	..	1.0	36.9	..	0.0	33.3	..	0.5	33.6
Maitland....	..	1.9	42.4	..	3.5	41.3	..	2.0	36.9	..	1.0	35.7	..	0.0	34.8	..	0.0	33.5
Nemzek.....	..	0.5	40.4	..	0.5	40.5	..	0.5	39.3	..	0.0	39.5	..	...	....	..	0.0	35.5
Lindsay.....	..	0.0	44.7	..	0.1	41.7	..	0.1	40.7	..	0.0	39.6	..	...	....	..	0.5	34.5
Veitch......	..	1.0	40.5	..	2.0	39.8	..	2.0	37.8	..	1.0	37.1	..	0.0	35.4	..	0.5	34.2
Chapman....	..	3.2	38.7	..	2.0	40.0	..	1.9	38.4	..	0.5	38.2	..	0.5	34.2	..	1.0	33.0
Edgerly.....	..	3.0	40.6	..	...	....	..	...	....	..	...	....	..	...	....	..	1.0	33.5
Johnson.....	39	...	....	39	...	....	39	...	....	39	...	....	..	...	....	39	...	....
Mackenzie...	..	0.0	40.6	..	0.0	40.6	..	0.0	36.6	..	0.0	36.6	..	0.0	35.1	..	0.5	35.4
Bacon.......	42	...	....	42	...	....	..	...	....	..	...	....	..	...	....	..	1.0	34.7
Lowest Lab. Average...			38.0			39.8			36.5			35.7			33.3			33.0
Highest Lab. Average...			45.2			43.7			40.7			40.2			35.4			35.5
Difference...			7.2			3.9			4.2			4.5			2.1			2.5
Average.....			41.3			41.4			38.4			37.9			34.6			34.2

SAMPLE NO. 2.

Operator.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent	Laboratory Average, deg. Cent.
Forrest......	..	2.0	30.1	..	2.0	30.2	..	2.0	25.1	..	1.0	24.4	..	0.0	22.2	..	0.5	22.5
Bragg.......	..	1.0	25.0	..	0.0	27.4	4	...	....	4	...	....	..	...	....	..	...	....
Weiss.......	7	2.0	29.6	..	2.0	26.5	8	1.0	24.1	..	0.0	24.5	..	...	....	..	0.0	20.7
Nuckolls....	..	2.0	27.2	..	2.0	26.3	..	1.0	23.0	..	0.0	22.3	..	0.0	21.2	..	0.6	21.7
Maitland....	..	0.0	26.2	..	1.0	26.6	..	...	....	..	...	....	..	0.0	21.8	..	0.1	21.1
Nemzek.....	..	0.0	25.3	..	0.0	25.3	..	0.0	24.3	..	0.0	24.8	..	...	....	..	0.5	21.7
Lindsay.....	..	0.0	28.6	..	0.0	28.6	..	0.0	25.6	..	0.0	24.6	..	...	....	..	0.0	21.2
Veitch......	..	2.0	26.6	..	1.0	26.9	..	2.0	24.6	..	0.0	23.6	..	0.0	22.3	..	0.5	22.1
Chapman....	..	...	....	..	...	....	..	...	....	..	...	....	..	1.0	22.3	..	0.5	21.1
Edgerly.....	..	1.0	25.6	..	...	....	..	...	....	..	...	....	..	...	....	..	0.5	21.7
Johnson.....	32	...	....	32	...	....	32	..	....	32	...	....	..	...	....	32	...	....
Mackenzie...	..	0.0	27.6	..	0.0	27.6	..	0.0	22.6	..	0.0	23.6	..	0.0	22.6	..	0.0	21.6
Bacon.......	..	1.0	29.2	..	1.2	29.0	..	...	....	..	...	....	..	...	....	..	1.0	21.4
Lowest Lab. Average...			25.0			25.3			22.6			22.3			21.2			20.7
Highest Lab. Average...			30.1			30.2			25.6			24.8			22.6			22.5
Difference...			5.1			4.9			3.0			2.5			1.4			1.8
Average.....			27.4			27.4			24.2			24.0			22.1			21.5

TABLE III.—SUMMARY OF RESULTS OF TESTS (*Continued*).

SAMPLE No. 3.

Operator.	Type of Tester																	
	Tagliabue Open.												Abel-Pensky.			Bureau of Mines.		
	Method No. 1.						Method No. 2.											
	Glass Cup.			Metal Cup.			Glass Cup.			Metal Cup.								
	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Test Nos. Eliminated from Average.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.
Forrest......	..	1.0	55.5	..	2.0	54.2	..	2.0	48.5	..	1.0	48.9	..	0.5	45.5	..	0.5	46.4
Bragg.......	..	0.0	51.7	..	1.0	49.9	4	...	....	4	...	....	..	...	....	..	...	....
Weiss.......	..	2.0	52.5	..	2.0	55.3	..	3.0	50.8	..	0.0	50.6	..	...	....	..	0.0	44.2
Nuckolls....	..	0.0	52.3	..	1.0	53.7	..	1.0	46.0	..	1.0	45.9	..	0.5	44.5	..	0.5	45.1
Maitland....	..	0.4	53.1	..	...	....	..	...	....	..	...	....	..	0.0	45.8	..	0.0	45.7
Nemzek.....	..	0.5	51.9	..	0.0	51.7	..	0.5	49.5	..	0.0	49.7	..	...	....	..	0.0	46.1
Lindsay.....	..	0.2	52.6	..	0.0	51.7	..	0.0	49.7	..	0.0	50.6	..	...	....	..	0.5	45.5
Veitch......	..	1.0	54.7	..	1.0	56.3	..	1.0	52.7	..	1.0	48.9	..	0.0	45.4	..	0.5	45.7
Chapman....	..	...	....	..	...	....	..	...	....	..	...	....	..	1.0	45.3	..	1.0	44.8
Edgerly.....	..	1.0	49.0	..	...	....	..	...	....	..	...	....	..	...	....	..	0.0	45.0
Johnson.....	28	...	....	28	...	....	28	...	....	28	...	....	..	...	....	28	...	....
Mackenzie...	..	0.0	52.6	..	0.0	51.6	..	0.0	46.6	..	0.0	45.6	..	0.0	46.6	..	0.0	46.6
Bacon.......	..	1.0	50.9	..	3.1	51.3	..	...	....	..	...	....	..	...	....	..	1.2	45.3
Lowest Lab. Average...			49.0			49.9			46.0			45.6			44.5			44.2
Highest Lab. Average...			55.5			56.3			52.7			50.6			46.6			46.6
Difference...			6.5			6.4			6.7			5.0			2.1			2.4
Average.....			52.4			52.9			49.1			48.6			45.5			45.5

In obtaining the laboratory average, certain tests were eliminated for the reasons noted in Table IV.

TABLE IV.—REASONS FOR ELIMINATING CERTAIN TESTS FROM COMPUTATION OF AVERAGES.

SAMPLE NO. 1.

Operator.	Test No.	Type of Tester.	Kind of Cup.	Method No.	Reasons.
Forrest......	1	Tagliabue Open	Metal	1	Higher than other check tests.
Bragg.......	4	Tagliabue Open	Metal	1	Higher than other check tests.
Johnson.....	39	....	....	..	Only one test reported on cups.
Bacon.......	42	....	....	..	Only one test reported on cups.

SAMPLE NO. 2.

Operator.	Test No.	Type of Tester.	Kind of Cup.	Method No.	Reasons.
Bragg.......	4	Tagliabue Open	Glass Metal	2	Only one test reported with each kind of cup.
Weiss.......	7	Tagliabue Open	Glass	1	Lower than other check tests.
Weiss.......	8	Tagliabue Open	Glass	2	Higher than other check tests.
Johnson.....	32	....	....	..	Only one test reported on cups.

SAMPLE NO. 3.

Operator.	Test No.	Type of Tester.	Kind of Cup.	Method No.	Reasons.
Bragg.......	4	Tagliabue Open	Glass Metal	2	Only one test reported with each kind of cup.
Johnson.....	28	....	....	..	Only one test reported on cups.

APPENDIX III.

TESTS OF 1917 SERIES.

The following directions for the 1917 series of tests were sent to every member of the sub-committee:

SAMPLES.

Sample No. 70 N.—One-gallon can of petroleum naphtha, marked No. 70 *N*, flash point about 22° C., closed cup; forwarded by Mr. F. C. Robinson of the Atlantic Refining Co.

Sample No. 80 B.—One-gallon can of coal-tar distillate, marked No. 80 *B*, flash point about 31° C., closed cup; forwarded by Mr. J. M. Weiss of the Barrett Co.

Sample No. 100 T.—One-gallon can of turpentine, marked No. 100 *T*, flash point about 33° C., closed cup; forwarded by Mr. D. W. Edgerly of The Debevoise Co. This material was furnished by the General Naval Stores Co.

Sample No. 1 S.—One-gallon can of petroleum distillate, marked No. 1 *S*, flash point about 34° C., closed cup; forwarded by Mr. K. G. Mackenzie of the Texas Co.

Sample No. 150 D.—One-gallon can of petroleum distillate, marked 150 *D*, flash point about 61° C., closed cup; forwarded by Mr. K. G. Mackenzie of the Texas Co.

TESTERS.

Tag Closed Tester.—We have several of these new testers loaned by the C. J. Tagliabue Manufacturing Co., which will be loaned to our members for these tests. The directions for operating this tester are enclosed. The tester is illustrated in Fig. 1.

Abel-Pensky Closed Tester.—With the Abel-Pensky tester, please be sure to note on report sheets whether it is an official German Abel-Pensky apparatus, and if the flash-point thermometer that came with the apparatus is used. For directions for operating use method No. I (Official Method) only, as given in directions for 1914 series of tests (see Appendix I). The temperatures at which tests should begin are given later under the description of tests.

TESTS.

Tests.—The following methods of operation should be strictly followed, and only tests conforming to these methods should be reported.

Barometer.—It is preferable that barometer readings be made in the laboratory at the time of making tests. If this is not available, the nearest weather bureau office can give you the information, but be sure and obtain same for the time of day that tests were made. For your information, 10 mm. difference in barometer readings makes approximately 0.°3 C. difference in flash point, and the barometer may change more than this during the day. Do not correct flash point obtained for barometer readings, as the sub-committee will do that.

Report Blanks.—Printed forms of the sub-committee are enclosed, marked for the two testers.

Temperatures for Use of Tag Closed Tester.—The following supplementary information as to temperatures will be found of value:

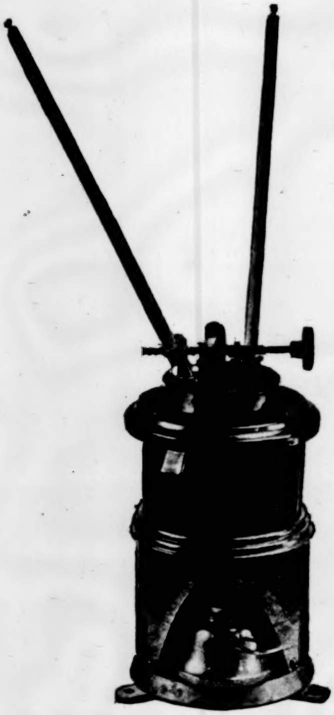

FIG. 1.—Tag Closed Tester.

The temperature of the water in the water bath for sample No. 70 *N* should be 12° C.; for sample No. 80 *B*, 21° C.; for sample No. 100 *T*, 23° C.; for sample No. 1 *S*, 24° C.; and for sample No. 150 *D*, 51° C.

The temperature of the liquid in the oil cup for sample No. 70 *N* should be 12° C.; for sample No. 80 *B*, 21° C.; for sample No. 100 *T*, 23° C.; for sample No. 1 *S*, 24° C.; and for sample No. 150 *D*, 51° C.

Sample No. 70 *N* should be first tested at 17° C., sample No. 80 *B* at 26° C., sample No. 100 *T* at 28° C., sample No. 1 *S* at 29° C., and sample No. 150 *D* at 56° C.

DIRECTIONS FOR OPERATING THE TAG CLOSED TESTER.

The test must be performed in a dim light so as to see the flash plainly.

Surround the tester on three sides with an inclosure to keep away drafts. A shield about 18 in. square and 2 ft. high, open in front, is satisfactory. But any safe precaution against all possible room drafts is acceptable. Tests made in a laboratory hood or near ventilators will give unreliable results.

See that tester sets firm and level.

For accuracy, the flash-point thermometers, which are especially designed for the instrument, should be used, as the position of the bulb of the thermometer in the oil cup is essential.

Water Bath.—Put the water-bath thermometer in place. Place a receptacle under the overflow spout to catch the overflow. Fill the water bath with water, at such a temperature that when testing is started, the temperature of the water bath will be at least 10° C. below the probable flash point of the oil to be tested.

Oil Cup.—Put the oil cup in place in the water bath. Measure 50 cc. of the oil to be tested in a pipette or a graduate, and place in oil cup. The temperature of the oil must be at least 10° C. below its probable flash point when testing is started. Destroy any bubbles on the surface of the oil.

Put on cover with flash-point thermometer in place and gas tube attached. Light pilot light on cover and adjust flame to size of the small white bead on cover.

Heating.—Light and place the heating lamp, filled with alcohol, in base of tester and see that it is centrally located. Adjust flame of alcohol lamp so that temperature of oil in cup rises at the rate of about 1° C. per minute, or not faster than 1° C., nor slower than 0.°9 C. per minute.

Testing.—Record the "time of applying the heating lamp;" record the "temperature of the water bath at start;" record the "temperature of the oil sample at start."

When the temperature of the oil reaches about 5° C. below the probable flash point of the oil, turn the knob on the cover so as to introduce the test flame into the cup, and turn it promptly back again. Do not let it snap back. The time consumed in turning the knob down and back should be about one full second, or the time required to pronounce distinctly the words "one-thousand-and-one."

Record the "time of making the first introduction of the test flame;" record the "temperature of the oil sample at time of first test."

Repeat the application of the test flame at every 0.°5 C. rise in temperature of the oil until there is a flash of the oil within the cup. Do not be misled by an enlargement of the test flame or halo around it when entered into the cup, or by slight flickering of the flame; the true flash consumes the gas in the top of the cup and causes a very slight explosion.

Record the "time at which the flash point is reached;" record the "flash point."

If the rise in temperature of the oil, from the "time of making the first introduction of the test flame" to the "time at which the flash point is reached" was faster than 1.°1 C. or slower than 0.°9 C. per minute, the test should be questioned, and the alcohol heating lamp adjusted so as to correct the rate of heating. It will be found that the wick of this lamp can be so accurately adjusted as to give a uniform rate of rise in temperature of 1° C. per minute and remain so.

Repeat Tests.—It is not necessary to turn off the test flame with the small regulating valve on the cover, leave it adjusted to give the proper size of flame.

Having completed the preliminary test, remove the heating lamp, lift up the oil-cup cover, and wipe off the thermometer bulb. Lift out the oil cup and empty and carefully wipe it. Throw away all oil samples after once using in making test.

Pour cold water into the water bath, allowing it to overflow into the receptacle, until the temperature of the water in the bath is lowered to 8° C. below the flash point of the oil as shown by the previous test. With cold water of nearly constant temperature it will be found that a uniform amount will be required to reduce the temperature of the water bath to the required point.

Place the oil cup back in the bath and measure into a 50-cc. charge of fresh oil. Destroy any bubbles on the surface of the oil, put on the cover with its thermometer, put in the heating lamp, record time and temperature of oil and water and proceed to repeat test as described above. Introduce test flame for first time at a temperature 5° C. below the flash point obtained on the previous test.

General.—Be sure to record barometric pressure either from laboratory barometer or from nearest Weather Bureau station. Record initials of Operator. Record temperature of room.

Note and record any flickering of the test flame or slight preliminary flashes when the test flame is introduced into the cup before the proper flash occurs. Record time and temperature of such flickers or slight flashes if they occur.

DIRECTIONS FOR OPERATION OF ABEL-PENSKY TESTER.

Use method No. I (Official Method) only, as given in directions for 1914 series of tests (see Appendix I).

The following are the sub-committee's supplementary notes to the official method as applying to the five samples under test:

Section 3.—Note that this applies to the temperature at which the release pin is first pressed; in other words, the start of test is from 13 to 17° C., depending on barometer reading at time of test. The above temperatures apply only to samples Nos. 70 *N* and 80 *B*, which are low flashing oils. On samples Nos. 100 *T*, 1 *S*, and 150 *D*, the test should be started by directions under Section 4, as these are higher flashing oils.

Section 4.—For samples Nos. 100 *T*, 1 *S*, and 150 *D*, make preliminary test for flash point (which will vary according to barometer) and start testing at 5 to 7° C. below this flash point, as stated in Section 4.

Section 6.—The water in the container should be at the following temperatures:

For sample No. 70 *N*	47 to 55° C.
" " " 80 *B*	56 to 64° C.
" " " 100 *T*	58 to 66° C.
" " " 1 *S*	59 to 67° C.
" " " 150 *D*	86 to 94° C.

Section 8.—The samples should be cooled or warmed to the following temperatures:

For sample No. 70 *N*	16° C.
" " " 80 *B*	25° C.
" " " 100 *T*	27° C.
" " " 1 *S*	28° C.
" " " 150 *D*	55° C.

Section 9.—The water bath should be heated to the following temperature, and during the test, should be kept at these temperatures:

For sample No. 70 *N*	52 to 58° C.
" " " 80 *B*	61 to 70° C.
" " " 100 *T*	63 to 72° C.
" " " 1 *S*	64 to 75° C.
" " " 150 *D*	91 to 100° C.

Section 13.—The release pin is pressed for first test at the following temperatures:

For sample No. 70 *N*	16° C.
" " " 80 *B*	25° C.
" " " 100 *T*	27° C.
" " " 1 *S*	28° C.
" " " 150 *D*	55° C.

The foregoing is for information only so to quickly give the determination of the correct temperatures which will be shown by your actual tests.

Do not correct for barometric pressure, as the sub-committee will do that.

RESULTS OF TESTS.

Tables I and II give the results of tests of the 1917 series of flash-point determinations.

In the laboratory averages of Tag Closed tester, the results of the U. S. Gutta Percha Paint Co. were not included, as they are high. This is due to slow rate of heating, as the time of the several tests varied from 7 to 16 minutes as compared to all other operators whose average was from 4 to 6 minutes.

TABLE I.—RESULTS OF TESTS.

TAG CLOSED TESTER.

Laboratory.	Initials of Operator.	Sample No. 70 *N.*		Sample No. 80 *B.*		Sample No. 1 *S.*		Sample No. 100 *T.*		Sample No. 150 *D.*	
		Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.
John T. Lucas & Co........	H. A. R	1.0	22.8	1.1	30.4	1.0	33.1	1.0	33.6	0.9	62.1
		1.0	22.3	1.0	30.4	1.0	33.1	1.1	34.1	0.9	61.9
		1.1	22.8	0.9	30.6	1.0	33.1	1.0	34.1	1.0	61.9
		1.0	22.8	1.0	30.7	...	....	...	....	...	....
Mass. Institute of Technology	E. D. H.	1.3	20.6	1.0	29.6	1.3	32.6	1.0	32.1	0.8	60.6
		1.6	20.6	1.1	31.1	0.9	32.3	1.1	32.1	0.7	61.1
		0.9	20.1	1.1	28.8	1.5	32.1	1.0	32.1	1.1	60.1
		...	....	1.4	29.1	0.8	32.6	...	....	1.2	60.6
U. S. Gutta Percha Paint Co.	W. W. R.	0.4	24.6	0.6	29.6	0.7	35.1	0.6	32.1	0.7	63.1
		0.4	25.1	0.7	30.1	0.8	35.1	0.7	32.1	0.7	62.1
		0.4	25.1	...	....	...	....	...	....	...	....
Underwriters Lab...........	W. K. M.	1.0	21.9	1.0	30.4	1.0	33.3	0.9	33.4	1.0	61.3
		0.8	22.4	0.8	30.4	1.0	33.3	0.9	32.9	1.0	60.8
		1.0	21.9	...	....	...	....	...	....	...	....
National Cash Register Co...	S. V. C.	1.0	21.5	0.9	29.7	0.9	33.0	0.9	33.2	0.8	60.5
		1.0	21.0	1.0	30.2	0.9	32.5	1.0	32.7	1.0	61.0
	A. B. B.	0.9	21.7	0.8	30.7	1.0	33.2	0.9	33.2	0.9	61.2
		1.2	21.7	1.0	30.2	1.0	32.7	0.8	33.2	0.9	61.2
Central Test Lab...........	C. C.	0.9	22.1	0.9	30.5	1.1	34.0	1.2	33.5	1.1	61.0
		1.1	22.1	0.9	30.5	0.9	33.5	1.0	33.5	1.2	61.5
Barber Asphalt Paving Co...	D. M.	1.3	21.7	1.5	28.7	...	....	...	....	...	....
		...	....	1.5	29.2	...	....	...	....	1.4	61.5
	McK.	1.3	21.7	1.0	29.7	1.7	32.5	1.3	32.0	1.1	61.5
		...	....	...	....	1.4	33.0	1.4	32.5	1.0	61.5
Lowe Bros. Co.............	H. M.	1.1	21.9	1.3	30.5	0.9	33.5	1.0	32.7	1.1	61.6
		1.1	21.9	0.9	31.0	1.1	33.0	1.1	33.7	1.0	61.6
		1.0	21.9	1.0	31.0	1.1	32.9	1.1	33.2	1.0	61.1
Atlantic Refining Co........	C. F. K.	1.0	23.8	0.9	29.6	0.9	33.7	1.0	32.6	0.8	60.2
		1.0	21.3	1.0	29.6	1.1	33.7	3.5	34.6	0.8	60.7
		0.9	22.3	...	....	...	....	1.2	32.6	0.8	60.2
		1.5	21.8	...	....	...	....	...	....	...	....
		0.9	21.8	...	....	...	....	...	....	...	....
		1.1	23.8	...	....	...	....	...	....	...	....
Sun Co....................	H. T. M.	1.4	22.1	0.8	30.3	1.1	33.0	1.3	33.6	1.0	62.0
		2.0	21.1	1.3	30.3	1.2	34.0	2.0	32.6	0.9	61.0
		1.2	22.2	...	....	1.4	33.7	1.0	33.6	1.0	62.0
		1.1	22.2	...	....	...	....	...	....	0.9	61.6
Bureau of Standards........	B.	0.9	21.4	1.1	30.3	1.0	33.2	1.0	33.2	1.0	60.8
		1.0	21.4	1.0	30.3	1.0	33.2	1.0	33.2	1.0	60.9
		1.0	21.4	...	....	0.9	32.7	...	....	...	....
Bureau of Chemistry........	G. C. S.	1.0	20.8	0.9	29.9	1.0	32.3	0.8	32.9	1.0	60.3
		1.0	21.3	1.0	29.9	1.3	32.2	1.1	31.9	1.0	60.8
		1.0	20.8	1.1	29.9	0.9	32.2	1.0	32.9	0.9	60.2
		...	....	...	....	...	....	1.0	32.4	...	....
Texas Co..................	J. C. K.	...	....	1.4	31.3	0.9	35.3	0.9	34.3	1.0	61.8
		...	....	0.9	31.3	0.9	35.3	0.8	34.3	1.0	61.3
AVERAGE...............	....	......	22.0	......	30.2	......	33.3	......	33.1	......	61.2

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[1] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

TABLE I.—RESULTS OF TESTS (*Continued*).

ABEL-PENSKY TESTER.

Laboratory.	Initials of Operator.	Sample No. 70 *N*.		Sample No. 80 *B*.		Sample No. 1 *S*.		Sample No. 100 *T*.		Sample No. 150 *D*.	
		Rise in Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test deg. Cent.	Flash Point,[1] deg. Cent.	Rise of Temperature per Minute during Test, deg. Cent.	Flash Point,[1] deg. Cent.
John T. Lucas & Co.	H. A. R.	...	22.3	...	30.3	...	33.4	...	32.8	...	....
		...	22.3	...	31.3	...	33.9	...	33.4	...	....
		...	22.8	...	31.3	...	33.9	...	32.9	...	....
		...	22.8	...	31.3	...	33.9	...	32.9	...	....
Mass. Institute of Technology	E. D. H.	1.5	22.0	1.4	30.5	1.2	34.0	3.6	33.5	0.3	63.5
		1.3	21.0	1.5	31.0	1.1	35.5	1.3	33.5	0.4	63.9
		1.5	22.0	1.4	30.5	1.4	35.0	0.9	32.5	0.5	63.9
U. S. Gutta Percha Paint Co.	W. W. R.	0.7	20.6	1.0	30.1	0.9	34.1	0.9	33.6	...	....
		0.7	21.1	0.9	29.6	1.1	34.6	0.9	33.1	...	....
Underwriters Lab.	W. K. M.	2.2	23.3	1.8	31.8	1.8	35.2	1.8	35.7	1.2	63.2
		1.9	22.8	1.8	31.8	1.7	34.7	1.5	35.7	1.1	63.2
		...	....	...	....	...	....	2.2	35.7	...	....
National Cash Register Co.	S. V. C.	1.8	22.5	1.4	31.5	1.7	36.0	1.1	35.0	...	....
		2.0	23.0	1.6	31.5	1.6	35.5	1.2	34.5	...	....
		2.6	23.5	...	....	...	....	...	....	...	....
	A B. B.	1.9	23.4	1.6	31.0	1.1	34.0	1.4	34.0	...	....
		1.7	22.4	1.6	31.0	1.4	34.0	1.2	34.0	...	....
		1.8	23.0	...	....	...	....	...	....	...	....
Central Testing Lab.	C. C.	1.6	22.1	1.3	31.5	1.6	33.8	1.2	33.8	0.9	63.4
		1.6	22.1	1.4	31.5	1.3	33.3	1.2	33.8	0.8	62.9
Barber Asphalt Paving Co.	D. M.	1.7	22.0	...	....	...	....	1.9	34.7	...	....
		1.1	22.5	...	....	...	....	1.6	33.7	...	....
		...	....	...	....	...	....	0.8	33.7	...	....
	McK.	...	....	2.0	29.2	1.1	33.7	1.1	33.7	0.5	63.3
		...	....	1.0	30.1	1.0	33.7	1.4	34.2	0.8	63.3
		...	....	1.8	28.6	...	....	...	....	...	....
		...	....	1.3	29.2	...	....	...	....	...	....
Lowe Bros. Co.	H. M.	1.5	22.5	1.6	32.0	1.4	34.9	1.7	35.0	0.8	64.4
		2.0	22.5	1.6	32.0	1.4	35.4	1.6	34.5	0.7	65.4
		1.8	22.0	1.5	31.5	1.4	34.9	1.5	35.5	0.6	64.4
Atlantic Refining Co.	C. F. K.	2.0	22.0	1.8	29.5	1.2	32.8	1.5	32.8	...	....
		2.0	21.5	1.8	29.5	1.1	32.8	1.4	32.8	...	....
		2.0	21.0	...	....	...	....	1.3	32.8	...	....
		1.8	21.5	...	....	...	....	...	....	...	....
		1.7	21.5	...	....	...	....	...	....	...	....
		1.8	21.5	...	....	...	....	...	....	...	....
Sun Co.	H. T. M.	1.3	23.8	1.1	32.7	0.8	34.7	1.0	35.8	...	....
		1.3	23.6	0.9	32.2	1.0	34.2	0.9	33.4	...	....
		1.1	23.6	...	....	...	....	1.1	34.4	...	....
		...	....	...	....	...	....	0.9	34.6	...	....
Bureau of Standards	B.	1.5	22.9	2.0	31.3	1.4	33.7	1.3	34.3	0.9	63.4
		1.8	23.4	1.5	30.8	1.4	33.8	1.2	34.3	0.8	64.4
		...	....	2.0	31.3	1.4	33.8	...	....	0.9	63.9
Bureau of Chemistry	G. C. S.	...	21.4	...	30.4	...	34.9	...	34.5	...	63.5
		...	21.9	...	30.9	...	33.9	...	34.0	...	63.5
		...	....	...	....	...	33.5	...	....	...	63.5
Texas Co.	J. C. K.	...	....	1.0	30.8	1.0	33.8	1.0	33.8	1.1	63.8
		...	....	1.2	30.8	1.6	34.3	1.0	33.8	1.1	63.8
AVERAGE			22.3		30.9		34.2		34.0		63.7

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[1] Corrected by sub-committee for barometric pressure. All flash points are given as of 760 mm. atmospheric pressure.

TABLE II.—SUMMARY OF RESULTS OF TESTS.

TAG CLOSED TESTER.

Laboratory.	Sample No. 70 *N*.		Sample No. 80 *B*.		Sample No. 1 *S*.		Sample No. 100 *T*.		Sample No. 150 *D*.	
	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average, deg. Cent.	Difference between Lowest and Highest Readings, deg. Cent.	Laboratory Average deg. Cent.
[1]John T. Lucas & Co.	0.5	22.7	0.3	30.5	0.0	33.1	0.5	33.9	0.2	62.0
Mass. Institute of Technology	0.5	20.4	2.3	29.7	0.5	32.4	0.0	32.1	1.0	60.6
U. S. Gutta Percha Paint Co.	...	....	...	....	...	....	...	....	...	....
[1]Underwriters Laboratory	0.5	22.1	0.0	30.4	0.0	33.3	0.5	33.2	0.5	61.0
National Cash Register Co.	0.7	21.5	1.0	30.3	0.7	32.9	0.5	33.1	0.7	61.0
Central Testing Lab.	0.0	22.1	0.0	30.5	0.5	33.8	0.0	33.5	0.5	61.3
[1]Barber Asphalt Paving Co.	0.0	21.7	1.0	29.2	0.5	32.8	0.5	32.3	0.0	61.5
Lowe Bros. Co.	0.0	21.9	0.5	30.8	0.6	33.1	1.0	33.2	0.5	61.4
[1]Atlantic Refining Co.	2.5	22.5	0.0	29.6	0.0	33.7	2.0	33.3	0.5	60.4
[1]Sun Co.	1.1	21.9	0.0	30.3	1.0	33.5	1.0	33.3	1.0	61.7
[1]Bureau of Standards	0.0	21.4	0.0	30.3	0.5	33.0	0.0	33.2	0.1	60.9
[1]Bureau of Chemistry	0.5	21.0	0.0	29.9	0.1	32.2	1.0	32.5	0.5	60.4
[1]Texas Co.	...	....	0.0	31.3	0.0	35.3	0.0	34.3	0.5	61.6
Lowest Lab. Average	......	20.4	......	29.2	......	32.2	......	32.1	......	60.4
Highest Lab. Average	......	22.7	......	31.3	......	35.3	......	34.3	......	62.0
Difference	......	2.3	......	2.1	......	3.1	......	2.2	......	1.6
AVERAGE	......	21.8	......	30.3	......	33.3	......	33.2	......	61.2
ABEL-PENSKY TESTER.										
[1]John T. Lucas & Co.	0.5	22.5	1.0	31.1	0.5	33.8	0.6	33.0	...	....
Mass. Institute of Technology	1.0	21.7	0.5	30.7	1.5	35.0	1.0	33.2	0.5	63.8
U. S. Gutta Percha Paint Co.	0.5	20.9	0.5	29.8	0.5	34.4	0.5	33.4	...	....
[1]Underwriters Laboratory	0.5	23.1	0.0	31.8	0.5	35.0	0.0	35.7	0.0	63.2
National Cash Register Co	1.1	23.0	0.5	31.3	2.0	34.9	1.0	34.4	...	....
Central Testing Lab.	0.0	22.1	0.0	31.5	0.5	33.6	0.0	33.8	0.5	63.2
[1]Barber Asphalt Paving Co.	0.5	22.3	1.5	29.3	0.0	33.7	1.0	34.0	0.0	63.3
Lowe Bros. Co.	0.5	22.3	0.5	31.8	0.5	35.1	1.0	35.0	1.0	64.6
[1]Atlantic Refining Co.	1.0	21.5	0.0	29.5	0.0	32.8	0.0	32.8	...	....
[1]Sun Co.	0.2	23.7	0.5	32.5	0.5	34.5	2.4	34.6	...	....
[1]Bureau of Standards	0.5	23.2	0.5	31.1	0.1	33.8	0.0	34.3	1.0	63.9
[1]Bureau of Chemistry	0.5	21.7	0.5	30.6	1.0	34.4	0.5	34.3	0.0	63.5
[1]Texas Co.	...	....	0.0	30.8	0.5	34.1	0.0	33.8	0.0	63.8
Lowest Lab. Average	......	20.9	......	29.3	......	32.8	......	32.8	......	63.2
Highest Lab. Average	......	23.7	......	32.5	......	35.0	......	35.7	......	64.6
Difference	......	2.8	......	3.2	......	2.2	......	2.9	......	1.4
AVERAGE	......	22.3	......	30.9	......	34.2	......	34.0	......	63.7

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[1] Laboratory of sub-committee member.

REPORT OF SUB-COMMITTEE XIV ON THE PREPARATION OF IRON AND STEEL SURFACES FOR PAINTING.

The sub-committee begs to report as follows:

At the meeting of Committee D-1 which was held in April, 1916, a tentative schedule of tests[1] proposed by Sub-Committee XIV was unanimously approved. During the year, the provisions of the schedule have been carefully carried out, with very few unimportant modifications; also two additional tests, not provided for in the schedule, were introduced. These two tests were as follows:

Test No. 11 consisted of cleaning the surfaces by the pickling process, using warm 10-per-cent solution of sulfuric acid, the panels being immersed in the acid till the rust and scale were removed, after which the acid was washed off of the surface by means of cold water discharged upon it from a hose under a pressure of 125 lb. per sq. in., the object being to remove all "colloidal iron sulfate solution."[2]

Test No. 16 was prepared by purposely imperfectly sandblasting the surfaces, some spots of mill scale being left to give an opportunity for local electrolytic action. The surfaces were painted immediately thereafter indoors, in a warm, dry atmosphere.

It might also be stated that panels for scheduled test A-5 and A-6 were cleaned as specified in warm 10-per-cent solution of sulfuric acid to remove all rust and scale, after which they were immediately removed and rinsed under a stream of hot water, dipped in a 10-per-cent solution of carbonate of soda, then washed under a stream of hot water and finally allowed to dry.[2]

The steel panels used were furnished by the Pennsylvania Railroad Co. The sheets used in test series A were all from the same heat of steel and were 24 by 36 by $\frac{1}{8}$ in. thick. A sheet taken from this heat of steel was subjected to chemical analysis in the laboratory of the Pennsylvania Railroad Co., from which the following results were obtained:

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[1] Appendix, Report of Sub-Committee XIV of Committee D-1, *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 296 (1916).

[2] *Ibid.*, p. 298.

Carbon	0.107 per cent
Manganese	0.42 "
Silicon	0.008 "
Phosphorus	0.008 "
Sulfur	0.032 "
Copper	0.031 "

The sheets used in test series B were from old freight cars, from which approximately 10 to 25 per cent of the surface had become rusty in spots which it is believed were started by mechanical injury. The sheets were 20 by 30 by $\frac{1}{8}$ in. thick. The panels were not necessarily from the same heat of steel, but they were all rolled under the same specifications and an extra sheet taken at random for chemical analysis gave the following results:

Carbon	0.134 per cent
Manganese	0.42 "
Silicon	0.009 "
Phosphorus	0.015 "
Sulfur	0.037 "
Copper	0.031 "

The paint used was manufactured and donated by Mr. F. P. Cheesman. In the preparation of the paint, a paste was first made by grinding the following mixture:

Red oxide of iron	105 lb.
Ochre, B. F	100 "
Whiting, X. G	10 "
Silica	208 "
Raw linseed oil	141 "

The ready-mixed paint was made by thinning 32 lb. of the above paste with $8\frac{1}{2}$ lb. of raw linseed oil, and 3 lb. of Cheesman & Elliot's No. 2 Kauri Gum Japan. The weight of the ready mixed paint was $12\frac{1}{4}$ lb. per gal.

An analysis which was made in the laboratory of the Pennsylvania Railroad Co. showed the pigment in the paint to contain 26.50 per cent of sesqueoxide of iron, 3.86 per cent of calcium carbonate, and no sulfates.

The oil was found to be free from volatile matter, foots and metallic oxides, while the Maumené test showed a rise of temperature from 80 to 180° F. The iodine number was found to be 178.

The Japan dryer used contained 70.47 per cent of turpentine, and 29.53 per cent of non-volatile base containing lead, manganese, oil and Kauri Gum. The theoretical composition of the ready-mixed paint was:

Pigment	55.17	per cent
Raw linseed oil	37.93	"
Japan base	2.04	"
Turpentine from Japan	4.86	"

The paint was applied as received, except that to the priming coat $\frac{1}{8}$ oz. of lamp black and raw-linseed-oil paste was added to each pound of paint in accordance with the tentative schedule of tests.

A meeting of the sub-committee was held January 15, 1917, at which time the panels were prepared and the paint applied. The members present were Messrs. Cheesman, Sabin and McDonnell. All brush applications were made by a skilled painter from the Altoona shops of the Pennsylvania Railroad Co., who applied the amount of paint which he considered proper. The amount used varied according to the condition of the respective panels, smooth surfaces requiring less than rough ones. The amount of paint used was determined by weight and recorded for each set of panels. The detail record of the preparation of all surfaces as outlined in the tentative schedule of tests is appended to this report.

The sub-committee feels that it is too early to determine what influence the various preliminary treatments of the surface will have on the durability of the paint films.

Respectfully submitted on behalf of the sub-committee,

A. W. CARPENTER,
Chairman.

APPENDIX.

RECORD OF PREPARATION AND PAINTING OF SURFACES AS OUTLINED IN TENTATIVE SCHEDULE OF TESTS.

SERIES A; NEW STEEL.

Test No. 1, Schedule No. A-1.—Two panels were painted as received from mill, with surfaces clean and free from rust, and with mill scale intact. First coat of paint was applied January 16, 1917, in a dry, warm room, the spreading rate being 888 sq. ft. per gal. The second coat was applied under same conditions on January 18, the spreading rate being 944 sq. ft. per gal.

Test No. 2, Schedule No. A-2.—Two panels were painted as received from the mill, with surface rather badly abraded, about 25 per cent of mill scale gone, and slightly rusted; also smeared with tallow, washed with benzine, scraped and gone over with a wire brush. The first coat of paint was applied in a warm, dry atmosphere on January 15, the spreading rate being 701 sq. ft. per gal. The second coat of paint was applied on January 18, the spreading rate being 951 sq. ft. per gal.

Test No. 3, Schedule No. A-3 (1).—Two panels, after being received from mill, were carefully sand blasted on January 16, and painted immediately thereafter in a warm, dry room, the spreading rate being 663 sq. ft. per gal. The second coat was applied 48 hr. later, the spreading rate being 906 sq. ft. per gal.

Test No. 4, Schedule No. A-3 (2).—Two panels, after being received from mill, were carefully sandblasted and heated immediately thereafter in an oven to 225° F. The first coat of paint was applied on January 16 while the plates were still warm, at the spreading rate of 854 sq. ft. per gal., while the rate on the second coat, applied 48 hr. later, was 944 sq. ft. per gal.

Test No. 5, Schedule No. A-3 (3).—Two panels as received from the mill were carefully sand-blasted, placed in a cool, damp room for 40 min. and painted therein on January 16, while the temperature was 43° F. The paint was allowed to dry in the same atmosphere. The spreading rate with the first coat was 619 sq. ft. per gal. The second coat of paint was applied 48 hr. later in the same cool, damp room, the temperature of which was 44° F., and allowed to dry therein. The spreading rate of the second coat was 793 sq. ft. per gal.

Test. No. 6, Schedule No. A-3 (4).—Two panels, as received from the mill, were carefully sand-blasted and placed out of doors, under cover, and painted on January 16—a cold, clear day, the temperature being 27° F. The spreading rate with the first coat was 518 sq. ft. per gal. The second coat was applied 72 hr. later, in a cold, dry atmosphere, the temperature of which was 25° F. at a spreading rate of 567 sq. ft. per gal. Both paint films were allowed to dry outside in the cold atmosphere in which the applications were made, and when hard were somewhat shriveled.

Test No. 7, Schedule No. A-4.—Two panels, as received from mill, were carefully sand-blasted on January 16, and allowed to stand out of doors exposed to the weather for seven days. Some rust developed during this exposure. On January 23, the panels were taken into a warm, dry room, and several hours later, without further cleaning, the first coat of paint was applied, at a spreading rate of 617 sq. ft. per gal. The second coat of paint was applied on January 25, the spreading rate being 1211 sq. ft. per gal.

Test No. 8, Schedule No. A-5.—Two panels, as received from mill, were immersed on January 15, in a 10-per-cent solution of sulfuric acid at a temperature of 116° F., and allowed to remain for 3 hr. This immersion completely removed the adhering scale and oxides. The panels were immediately rinsed under a stream of hot water, then immersed in a 10-per-cent solution of sodium carbonate for 5 min., and again washed under a stream of hot water. As soon as the panels were dry, the first coat of paint was applied in a warm, dry room. The spreading rate for this coating was 709 sq. ft. per gal. On the second coat which was applied January 17, the spreading rate was 906 sq. ft. per gal.

Test No. 9, Schedule No. A-6.—Two panels, as received from mill, were treated with acid and sodium carbonate, as in test No. 8, January 15, and then allowed to stand out of doors, exposed to the weather, for seven days. Some rust developed during this exposure. On January 23, the panels were taken into a warm, dry room and several hours later, without further cleaning, the first coat of paint was applied at a spreading rate of 666 sq. ft. per gal. On the second coat which was applied on January 25, the spreading rate was 1387 sq. ft. per gal.

Test No. 10, Schedule No. A-7.—Two panels, as received from mill with scale intact, were allowed to stand out of doors exposed to the elements from August 4, 1916, till January 16, 1917. They became deeply rusted during this time, especially along diagonal lines which were apparently incident to the process of manufacture. Between these lines a small amount of mill scale still remained intact. The panels were carefully scraped and wire-brushed, indoors, 15 to 20 min. of hard work being spent on each panel, and approximately a pint of scale and rust was removed from each. The first coat of paint was then immediately applied in the warm, dry room, the spreading rate being 508 sq. ft. per gal. On January 18, a second coat of paint was applied, the spreading rate being 799 sq. ft. per gal.

Test No. 11 (Not scheduled).—Two panels, as received from mill, were kept indoors and on January 15 were immersed in a 10-per-cent solution of sulfuric acid at a temperature of 116° F., and allowed to remain therein for 3 hr., this exposure being sufficient to dissolve or disintegrate all mill scale and rust. The panels were then removed from the acid and washed with a stream of cold water from a hose under a pressure of 125 lb. per sq. in., for the purpose of removing insoluble colloidal iron sulfate. The panels were then allowed to dry and the first coat of paint immediately applied in the warm, dry room. The spreading rate of this coat was 748 sq. ft. per gal. The second coat of paint was applied on January 17, the spreading rate being 854 sq. ft. per gal.

Test No. 16 (*Not scheduled*).—Two panels, as received from mill with scale intact, were kept indoors, and on January 16 were incompletely sand-blasted, leaving the old mill scale on approximately 20 per cent of the surface, giving a spotty appearance to the metal. The first coat of paint was applied immediately thereafter in the warm, dry room, the spreading rate being 736 sq. ft. per gal. The second coat of paint was applied 48 hr. later, the spreading rate being 900 sq. ft. per gal.

SERIES B; STEEL WHICH HAS BEEN PAINTED AND BECOME PARTLY RUSTED.

Test No. 12, Schedule No. B-1.—Two panels, approximately 25 per cent of the surface of which was bare and rusted in spots, were taken from an old steel gondola freight car. On January 17 they were carefully wire-brushed indoors. A small amount of oil on the ends of the panels, remaining after cutting and punching, was not removed. After brushing, the old paint, still adherent, covered approximately 50 per cent of the surface. The first coat of paint was applied in the warm, dry room, at a spreading rate of 514 sq. ft. per gal. The second coat of paint was applied on January 19, at a spreading rate of 744 sq. ft. per gal.

Test No. 13, Schedule No. B-2.—Two panels, approximately 25 per cent of the surface of which was bare and rusted in spots, were removed from an old steel gondola freight car. On January 17 the panels were washed with benzine to remove adherent grease, which left from cutting and punching operations. The panels were then carefully scraped and wire-brushed. After the cleaning operation, the old paint, still adherent, covered about 50 per cent of the surface. The first coat of paint was applied in the warm, dry room as soon as the cleaning operations had been completed. The spreading rate at which the paint was applied was 612 sq. ft. per gal. The second coat of paint was applied on January 19, at a spreading rate of 841 sq. ft. per gal.

Test No. 14, Schedule No. B-3.—Two panels, approximately 10 per cent of which was bare and rusted in spots, were taken from an old gondola freight car and on January 17, indoors, were brushed-coated with benzine over and around all rust spots. A gas torch flame was then applied to the rusted places, and the edge of the old paint film surrounding same. The surface was then scraped and wire-brushed. The old paint remaining was adherent. The first coat was applied immediately in the warm, dry room, the spreading rate being 625 sq. ft. per gal. The second coat was applied on January 19, at a spreading rate of 835 sq. ft. per gal.

Test No. 15, Schedule No. B-4.—Two panels, approximately 50 per cent of the surface of which was bare and rusted, were removed from an old steel gondola freight car. On January 16, they were carefully sand-blasted in a warm, dry room, and about 3 hr. later were painted. The first coat had a spreading rate of 670 sq. ft. per gal. The second coat of paint was applied on January 18, at a spreading rate of 864 sq. ft. per gal.

All of the above panels were kept in the room or place where the first coat of paint was applied until the second coat had dried for 48 hr., except those of test No. 6, which required 72 hr. to dry. They were then assembled on a rack, out of doors, but under a roof. On February 1, the duplicate set of panels was sent to Mr. Cheesman in Brooklyn. On February 9, one set of the panels was placed on a permanent test rack, which is located on the roof of one of the shops of the Pennsylvania Railroad Co. in Altoona, Pa. On the same date the duplicate set of panels was placed on a permanent rack located on the roof of the Cheesman & Elliot factory, near the U. S. Navy Yard in Brooklyn.

REPORT OF SUB-COMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THE FORM.

Sub-Committee XV has held three meetings during the past year and as a result, desires to recommend the following points for use in specifications for pigments:

1. In definitions, the composition should be shown only to the extent that it is necessary to complete the definition.

2. A list should be given of the important other names in common use, but not recommended for use in specifications.

3. When a name given in the list of other names is copyrighted, it shall be printed in italics and attention called to the fact by an appropriate footnote.

4. In descriptive matter no mention should be made of objectionable impurities.

The sub-committee also wishes to recommend the following names and definitions for use in specifications:

Basic-Carbonate White Lead.—A white pigment having approximately the composition shown by the formula $2\,PbCO_3.Pb(OH)_2$; known also as lead, white lead, corroded lead, corroded white lead, basic lead carbonate, hydrated carbonate of lead, lead carbonate and carbonate white lead.

Basic-Sulfate White Lead.—A white pigment consisting essentially of basic sulfate of lead; known also as lead, white lead, *Sublimed Lead,*[1] *Sublimed White Lead,*[1] basic lead sulfate and sulfate of lead.

Zinc Oxide.—A white pigment containing not less than 98 per cent of zinc oxide and not more than 0.5 per cent of any other one metal; known also as zinc, oxide of zinc, zinc white, white zinc, American-process zinc oxide and French-process zinc oxide.

Leaded Zinc Oxide.—A white pigment composed of zinc oxide and lead sulfates. There are two varieties, namely, (1) low-leaded, containing not more lead than the equivalent of

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[1] Copyrighted.

5 per cent of lead sulfate; and (2) high-leaded, containing more lead than the equivalent of 5 per cent of lead sulfate. Known also as zinc lead, leaded zinc and zinc lead white.

Lithopone.—A white pigment composed of zinc sulfide and barium sulfate in approximately equal molecular proportions, and obtained by simultaneous precipitation and subsequent calcination; has no other names.

Barium Sulfate.—A white pigment of the composition $BaSO_4$. There are two varieties, namely, (1) barytes, the natural mineral; and (2) blanc fixe, an artificial form produced by precipitation. Has no other names.

Silica.—A white pigment consisting essentially of SiO_2. There are two varieties, namely, (1) crystallin, composed substantially of SiO_2; and (2) amorphous, contains combined water and not less than 75 per cent of SiO_2. Known also as Silex.

Calcium Carbonate.—A white pigment consisting essentially of $CaCO_3$ (part of the calcium may be replaced by magnesium). There are three varieties, namely, (1) that made from one of the soft natural varieties, such as chalk, and known as whiting; (2) that made from one of the hard limestones or marbles and frequently known as mineral primer; and (3) that made by precipitation. Known also as chalk, whiting, Paris white, Spanish white, English white and marble dust.

Calcium Sulfate.—A white pigment consisting essentially of $CaSO_4.2H_2O$, sometimes dehydrated; known also as terra alba and gypsum.

Magnesium Silicate.—A white pigment made from a natural silicate of magnesium; known also as *Asbestine*,[1] talc and silicate of magnesia.

Aluminum Silicate.—A white pigment consisting essentially of hydrated silicate of aluminum; known also as China clay, kaolin and silicate of alumina.

The sub-committee desires to report progress on the preparation of the specifications for these pigments.

Respectfully submitted on behalf of the sub-committee,

G. C. STONE,
Chairman.

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[1] Copyrighted.

ADDENDUM

TO

REPORT OF COMMITTEE D-1.

At a meeting of Committee D-1 held at Atlantic City on Wednesday, June 27, 1917, the following amendments to the annual report of the committee as prepared for advance distribution were adopted:

Proposed Revisions in the Methods for Routine Analysis of White Pigments.[1]

The committee recommends that the sentence "Volume or apparent specific gravity shall be determined by the Scott Volumeter," immediately following the heading "General Method" at the top of page 537, 1916 Proceedings, Volume XVI, Part I, be omitted in referring these methods to letter ballot of the Society for adoption as standard.

Proposed Revisions in the Methods for Routine Analysis of Dry Red Lead.[2]

The committee recommends that the words "Apparent gravity and true specific gravity determined as per methods under white pigments," line 2, page 281, 1914 Proceedings, Volume XIV, Part I, be replaced by the words:

"Determine true specific gravity by means of a pyknometer, using c. p. benzine and 20 g. of pigment, or by Thompson's method.[3]

On page 281, omit lines 4 and 5 relative to the fineness test.

Editorial Note.

The proposed Standard Methods for Routine Analysis of White Pigments referred to in this report, as amended in the Addendum to the report, the proposed Standard Tests for Paint

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 536 (1916).

[2] *Ibid*, Vol. XIV, Part I, p. 281 (1914).

[3] *Ibid*, Vol. XIII, p. 407 (1913).

Thinners other than Turpentine, and the proposed Standard Tests for Shellac, were approved at the annual meeting, and subsequently adopted by letter ballot of the Society on August 15, 1917. They appear in a pamphlet entitled "A.S.T.M. Standards adopted in 1917," supplementary to the 1916 Book of A.S.T.M. Standards.

The two tentative methods referred to in the report, as amended in the Addendum to the report, were accepted for publication among the Tentative Standards of the Society, and appear on pages 796–809.

REPORT OF COMMITTEE D-2
ON
LUBRICANTS.

Since its report to the Society in 1915, Committee D-2 has continued work on the tests for lubricants mentioned therein, as well as additional tests. During this period the scope of the committee has been changed from that of a committee on standard tests for lubricants to a committee on lubricants. The committee hopes, therefore, to take up the question of specifications for lubricants as soon as standard methods of test can be adopted.

Specific Gravity.—The committee is presenting to the Society for publication as a tentative standard, a method for the determination of specific gravity, which appears as part of the proposed Tentative Tests for Lubricants appended to this report.

Viscosity.—The committee has been cooperating with the Bureau of Standards on the further standardization of the Saybolt Standard Universal Viscosimeter, and this work is still in progress.

The committee feels, however, that for the sake of uniformity, some action should be taken upon standard temperatures for viscosity. It is possible, by the use of the tables presented to the Society in 1915,[1] to convert viscosities on one instrument into viscosities on other instruments at the same temperature; but it is impossible to convert a viscosity reading taken at one temperature on one instrument into a viscosity reading at another temperature on a second instrument. The temperatures in most general use in this country are 70, 100, 130 and 210° F., but numerous other arbitrary temperatures are used to a certain extent, resulting in great confusion. In view of the fact that the tendency, both in the Society and the country at large, is toward the adoption of the Centigrade scale, it is recommended that the Centigrade temperatures nearest approaching these Fahrenheit temperatures in round numbers, be adopted. Thus:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, pp. 284–294 (1915).

20° C. = 68° F.
40° C. = 104° F.
55° C. = 131° F.
100° C. = 212° F.

Cloud and Pour Test.—Since the presentation of the 1915 report, the committee has carried on further work on this test. The test presented to the Society at that time was referred back to the committee on the basis of two minority reports, one objecting to the heating of the oil to 150° F., and the other to the method itself, compared with another method in use to a certain extent in this country. This other test consists, briefly, in cooling the sample until solid and then stirring until it flows, the temperature being recorded at this point.

The work of the committee has covered the proposed method, both with and without heating to 150° F., and the method of stirring which is termed the minority method. No one method appears to give for all oils the information sought by this test, and it is believed desirable to make a division into groups of the oils to be tested.

The steam cylinder and black oils change on remaining stationary for a time, because of their waxy structure. By first freezing and then stirring, according to the minority method, the softening point is learned.

The cloud and pour tests of oils other than these, when carried out by the method proposed by the committee in 1915, give definite information as to the permanent characteristics of the oil. The pour test represents the temperature at which the oil is fluid.

While this division requires familiarity with two methods, numerous comparative tests seem to leave no alternative. It is therefore proposed that the cloud and pour test be applied to all oils other than steam cylinder and black oils; and that these latter be tested by the freezing and stirring method.

The committee, therefore, presents to the Society for adoption as a tentative standard a cloud and pour test for petroleum oils except steam cylinder and black oils, this method being the method proposed in 1915 with the omission of the preheating to 150° F.; and a cold test for steam cylinder and black oils.

Evaporation.—While the committee cannot at this time propose a definite method for evaporation, it presents herewith the results so far obtained.

Three samples of lubricating oils marked No. 1 Light, No. 2 Medium, and No. 3 Heavy, and four aluminum dishes, two with square corners and two with round corners, were sent to five cooperating laboratories.

The properties of the oils were as follows:

Property.	No. 1 Lignt.	No. 2 Medium.	No. 3 Heavy.
Flash point, open cup, deg. Fahr.	395	445	560
Specific Gravity at 60° F., deg. Baume	31.4	28.75	27.5
Viscosity, Universal 100° F	146	458	...
" " 212° F	35	56	160

The approximate weight and dimensions of the aluminum dishes were as follows:

Dish.	Weight, g.	Outside Diameter, mm.	Inside Diameter, mm.	Inside Height, mm.	Thickness of Metal, mm.
Square, 1 and 2	14.50	65.5 - 66.0	64.5 - 65.0	18.5 - 19.0	1.0
Round, 3 and 4	10.50	64.0 - 65.0	63.0 - 64.0	15.5 - 16.0	1.0

A brief description of the air baths used by the five laboratories making comparative evaporation tests follows.

Laboratory A.—An electrically heated air bath about 8 in. square with stationary shelf placed about 4 in. from the top, lid provided with four holes about 1 in. in diameter. These were left open during the test. Oven provided with revolving fan under shelf.

Laboratory B.—Freas electrically heated oven, inside dimensions 12 in. wide, 12¾ in. deep and 14 in. high, provided with revolving shelf[1] having several rows of 1-in. holes. Thermometer placed near top and bottom. In the first series of tests the average temperature readings of the top and bottom thermometers were given. In the second series only the readings from the top thermometer were noted. This thermometer is about 5 in. above the dishes on the shelf.

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[1] See 1916 book of A. S. T. M. Standards, p. 534, for a description of this shelf.

Laboratory C.—Freas electrically heated oven, inside dimensions 18 in. high, 14 in. wide, 17 in. deep, with shelf about 9 in. from the top, not revolving. Oven provided with four ventilators of which one was left open during tests.

Laboratory D.—Cylindrical upright gas heated air bath, 10 in. diameter, 10 in. high, supplied with cast-iron stationary shelf 9¾ in. in diameter, ⅜ in. thick, perforated with row of ⅜-in. holes. Shelf placed 4 in. from the top, oven provided with a fan placed under shelf. The temperature control was poor.

Laboratory E.—Electrically heated circular oven 8 in. in diameter, 9 in. deep, provided with revolving shelf and lid as well as with a fan. These were arranged so they could revolve independently of one another. Dishes supported on perforated shelf but resting directly on a thin metal sheet, bath provided with a 1-in. air inlet pipe at bottom and lid with four 1-in. holes, which were partly closed during the test.

Five grams of oil were used in the test. The air baths were allowed to come to the desired temperature before inserting the dishes with the oil.

The results of the tests are given in Tables I to IV, inclusive.

TABLE I.—OIL NO. 1, AT 212° F. FOR 7 HOURS.

Laboratory.	Barometric Pressure, in.	Dishes.	Loss, per cent.	Average Loss, per cent.
A........................	30.04 - 29.84	1 and 2	0.18 - 0.16	0.170
		3 " 4	0.16 - 0.19	0.175
B........................	30.10 - 29.84	1 " 2	0.174 - 0.160	0.167
		3 " 4	0.182 - 0.180	0.181
C........................	30.50	1 " 2	0.140 - 0.150	0.145
		3 " 4	0.150 - 0.160	0.155
D........................	29.70 - 29.65	1 " 2	2.00 - 1.99	1.995
		3 " 4	1.93 - 1.94	1.935
E.	28.75 - 29.20	1 " 2	0.212 - 0.170	0.191
		3 " 4	0.200 - 0.184	0.197
	29.35 - 29.35	1 " 2	0.164 - 0.190	0.177
		3 " 4	0.182 - 0.180	0.181

TABLE II.—OIL NO. 1, AT 250° F. FOR 3 HOURS.

Laboratory.	Barometric Pressure, in.	Dishes.	Loss, per cent.	Average Loss, per cent.
A	.....	1 and 2	0.21 - 0.18	0.195
		3 " 4	0.22 - 0.19	0.205
	29.57	1 " 2	0.22 - 0.18	0.20
		3 " 4	0.19 - 0.20	0.195
B	30.09 - 29.91	1 " 2	0.296 - 0.314	0.305
		3 " 4	0.330 - 0.332	0.331
	30.38 - 30.33	1 " 2	0.356 - 0.402	0.379
		3 " 4	0.424 - 0.394	0.409
C	30.50	1 " 2	0.16 - 0.16	0.16
		3 " 4	0.16 - 0.17	0.165
D	29.55	1 " 2	4.11 - 3.95	4.02
		3 " 4	3.60 - 3.64	3.62
	29.45	1 " 2	5.79 - 6.36	6.07
		3 " 4	6.86 - 6.49	6.67
E	29.35 - 29.35	1 " 2	0.282 - 0.304	0.293
		3 " 4	0.312 - 0.318	0.315
	29.11 - 29.11	1 " 2	0.304 - 0.336	0.320
		3 " 4	0.340 - 0.354	0.347

TABLE III.—OIL NO. 2, AT 300° F. FOR 3 HOURS.

Laboratory.	Barometric Pressure, in.	Dishes.	Loss, per cent.	Average Loss, per cent.
A	29.96	1 and 2	0.25 - 0.21	0.23
		3 " 4	0.21 - 0.25	0.23
B	29.54 - 29.55	1 " 2	0.336 - 0.360	0.348
		3 " 4	0.378 - 0.376	0.377
	30.53 - 30.47	1 " 2	0.510 - 0.512	0.511
		3 " 4	0.532 - 0.530	0.531
C	30.38	1 " 2	0.34 - 0.35	0.345
		3 " 4	0.34 - 0.35	0.345
D	29.48	1 " 2	5.92 - 6.25	6.08
		3 " 4	4.67 - 4.64	4.65
	29.45	1 " 2	8.03 - 8.24	8.18
		3 " 4	10.40 - 9.64	10.02
E	29.02 - 29.02	1 " 2	0.424 - 0.418	0.421
		3 " 4	0.452 - 0.420	0.436
	29.34 - 29.28	1 " 2	0.490 - 0.490	0.490
		3 " 4	0.474 - 0.498	0.486

TABLE IV.—OIL NO. 3, AT 400° F. FOR 3 HOURS.

Laboratory.	Barometric Pressure, in.	Dishes.	Loss, per cent.	Average Loss, per cent.
A	29.27 - 29.23	1 and 2	0.25 - 0.20	0.225
		3 " 4	0.24 - 0.25	0.245
B	29.86 - 29.80	1 " 2	0.18 - 0.192	0.186
		3 " 4	0.194 - 0.190	0.192
	30.29 - 30.23	1 " 2	0.494 - 0.540	0.517
		3 " 4	0.550 - 0.524	0.537
C	30.38	1 " 2	0.58 - 0.59	0.585
		3 " 4	0.62 - 0.65	0.635
D	29.20	1 " 2	11.23 - 12.90	12.06
		3 " 4	8.89 - 11.46	10.67
	28.85	1 " 2	12.05 - 12.54	12.29
		3 " 4	12.38 - 11.90	12.14
E	29.02	1 " 2	0.420 - 0.430	0.425
		3 " 4	0.458 - 0.516	0.487
	29.10 - 29.10	1 " 2	0.520 - 0.512	0.516
		3 " 4	0.542 - 0.552	0.547

Following is a summary of the results:

Oil No. 1, at 212° F. for 7 hours.—Four laboratories, A, B, C and E give quite concordant results. Laboratory D report shows about ten times as much loss as the other four laboratories.

Oil No. 1, at 250° F. for 3 hours.—The variation of the percentage of loss with the different laboratories may be considered too great, therefore the proposed test of oil No. 1 for 3 hours at 250° F. cannot be considered satisfactory.

Oil No. 2, at 300° F. for 3 hours.—Three laboratories, B, C and E, are fairly close. D is entirely out of harmony with the rest and A rather low. This might be accounted for as having too wide an opening in the lid.

Oil No. 3 at 400° F. for 3 hours.—The comparative results show entirely too great variation between the different laboratories, although in each individual laboratory the results are quite concordant.

Carbon Residue.—After an extensive investigation of various methods, the committee is presenting to the Society a method for the determination of carbon residue of lubricants for adoption as tentative.

Free Acid.—The committee is presenting a method for the determination of free acid in lubricants, for adoption as tentative.

Emulsion.—The committee has under consideration the methods proposed by Mr. Conradson and Mr. Herschel[1] and also the method used by the United States Navy. The work has not progressed far enough to present definite recommendations.

Oxidation.—Considerable work has been done by the members of the committee on oxidation of lubricating oils at high temperatures. This work is still in progress and the committee hopes to present a definite method shortly.

Color.—The problem is to select and describe an instrument or instruments that will satisfactorily record color of lubricating oil.

The work so far has consisted in comparative readings from four prominent oil laboratories on oils from different crudes. It was found that the Lovibond Tintometer is used much more widely than any other apparatus, but that the color series used and depth of oil layer varied so much that proper comparison between the various laboratories was impossible. This shows that a much wider study of the method of using this apparatus will be necessary. The great difficulty encountered is common to all of the various forms of apparatus, namely, that oils from the different crudes do not have the same quality of color and therefore cannot be measured accurately with a single color standard (or by a series of color standards of the same quality of color but of varying intensity). In the opinion of the committee this difficulty is so serious that it will be desirable to await new ideas, particularly from the Bureau of Standards, before taking any action.

In conclusion, the committee recommends that the proposed Tentative Tests for Lubricants, appended to this report,[2] which comprise the six tests already referred to, be accepted for publication as tentative.

This report has been submitted to letter ballot of the committee, which consists of 21 members; 20 ballots were returned, and 1 member refrained from voting. The following is the result of the ballot:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, pp. 248–281 (1916).

[2] See pp. 767–772.—ED.

	AFFIRMATIVE.	NEGATIVE.	NOT VOTING.
General Report	19	0	1
Tentative Method for Specific Gravity	18	0	2
Tentative Standard Temperatures for Viscosity	16	0	4
Tentative Cloud and Pour Test for Petroleum Oils except Steam Cylinder and Black Oils	16	2	2
Tentative Cold Test for Steam Cylinder and Black Oils	15	3	2
Tentative Method for Free Acid	18	0	2
Tentative Method for Carbon Residue	17	0	3

Respectfully submitted on behalf of the committee,

C. P. VAN GUNDY,
Chairman.

K. G. MACKENZIE,
Secretary.

EDITORIAL NOTE.

The proposed tentative test referred to in this report was accepted for publication among the Tentative Standards of the Society, and appears on pages 767–772.

REPORT OF COMMITTEE D-4
ON
ROAD MATERIALS.

Committee D-4 begs to report as follows:

1. *Proposed Tentative Test for Toughness of Rock.*—As the result of over nine years' experience in routine testing laboratories and of a considerable amount of investigation, it has been thought desirable to revise the present Standard Test for Toughness of Macadam Rock[1] (Serial Designation: D 3–08), giving more complete and specific directions in connection therewith, and at the same time making the test more serviceable for ascertaining the relative toughness of different rocks. Committee D-4 therefore recommends that the proposed Tentative Test for Toughness of Rock as appended to this report[2] be published as tentative, for one year before referring it to letter ballot of the Society for adoption as standard.

2. *Proposed Revised Tentative Test for Determination of Apparent Specific Gravity of Coarse Aggregates.*—In its 1916 report, Committee D-4 proposed a Tentative Test for Determination of Apparent Specific Gravity of Homogeneous Coarse Aggregates[3] (Serial Designation: D 30–16 T), which was published among the tentative standards. While it is believed that this test is satisfactory for aggregates which are absolutely homogeneous, recent investigations have demonstrated that the homogeneity of an aggregate is frequently difficult to ascertain. It therefore recommends that the proposed revised tentative test, as appended to this report,[4] supersede the one presented in 1916, and that it be published as tentative, for one year before referring it to letter ballot of the Society for adoption as standard. The proposed revised tentative test is suitable not

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[1] 1916 Book of A.S.T.M. Standards, p. 526.

[2] See pp. 773–775.—Ed.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p 529 (1916).

[4] See pp. 776–777.—Ed.

only for homogeneous, but also for non-homogeneous coarse aggregates. In this connection it should be noted that the substitution of the proposed revised tentative test has also been recommended by the Joint Conference Committee consisting of members of Committee C-9 on Concrete and Concrete Aggregates and Committee D-4.

3. *Proposed Revision of the Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment*—In 1916 the Society adopted a Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment[1] (Serial Designation: D 20–16), which, from the standpoint of Committee D-4 alone, is perfectly satisfactory. In this method, the thermometer specified for use is described in Section 3 (*b*). In view of the fact, however, that a number of committees have recommended specifications for distillation thermometers which do not differ materially in essential requirements, but only in wording and minor details, a conference committee was appointed, consisting of members of Committee D-4, D-7 on Timber and D-1 on Preservative Coatings, to consider the existing specifications for distillation thermometers, and to present, if possible, a single specification to replace the three previously reported. The conference committee having agreed upon a common specification, Committee D-4 recommends a revision of the Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment, substituting the following thermometer specifications given in Appendix I to this report, for Section 3 (*b*) in the existing standard, and that this revision be published as tentative for one year prior to referring it to letter ballot of the Society for adoption as standard.

4. *Proposed Tentative Standard Definitions of Terms Applicable to Materials Relating to Roads and Pavements.*—The Joint Conference Committee, consisting of members of Committees C-9 and D-4, has given further consideration during the past year to the terms, Aggregate, Bank Gravel, Screen, and Sieve, and has proposed the following definitions, which have been accepted by Committee D-4, and are recommended for publication as tentative for one year before referring them to letter ballot of the Society for adoption as standard.

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[1] 1916 Book of A.S.T.M. Standards, p. 540.

Aggregate.—The inert material, such as sand, gravel, shell, slag or broken stone or combinations thereof, with which the cementing material is mixed to form a mortar or concrete.

Screen.—In laboratory work an apparatus, in which the apertures are circular, for separating sizes of material.

Sieve.—In laboratory work an apparatus, in which the apertures are square, for separating sizes of material.

Bank Gravel.—Gravel found in natural deposits, usually more or less intermixed with fine material, such as sand or clay, or combinations thereof; gravelly clay, gravelly sand, clayey gravel and sandy gravel, indicate the varying proportions of the materials in the mixture

5. *Report of the Conference Committee of Committees D-4 and C-9.*—In addition to its recommendations relative to the adoption of the Proposed Revised Tentative Method for Determination of Specific Gravity of Coarse Aggregates and the definitions above given, the Joint Conference Committee reports that it has under consideration methods proposed by Committee D-4 for the determination of the specific gravity of sand and other fine highway material, and of voids in mineral aggregates; that it also has under consideration definitions for filler, grit, loam, screenings, and silt. The Joint Conference Committee recommends that no definitions be adopted for gravel, sand and clay, and this recommendation has been accepted by Committee D-4. Because of the fact that the interests of both committees are affected by the matter, the Joint Conference Committee has under consideration the standardization of methods for sampling gravel, sand, and similar materials.

6. *British Standard Nomenclature of Bituminous Road Materials.*—In view of the fact that the Engineering Standards Committee of Great Britain has published a report upon "British Standard Nomenclature of Tars, Pitches, Bitumens and Asphalts," which, together with comments thereon, were referred to Committee D-4 for consideration, the committee submits a discussion of the British Standard Nomenclature as compared with the nomenclature adopted by the Society, which is given in Appendix II to this report.

The results of the letter ballot of the committee upon the recommendations which have been made affecting standards are as follows:

Recommendation.	Affirmative.	Negative.	Not Voting.
Proposed Tentative Test for Toughness of Rock	34	1	6
Proposed Revised Tentative Test for Determination of Apparent Specific Gravity of Coarse Aggregates	34	1	6
Proposed Revision in Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment	29	0	12
Proposed Tentative Definition of Aggregate	35	0	6
Proposed Tentative Definition of Bank Gravel	30	4	7
Proposed Tentative Definition of Screen	31	2	8
Proposed Tentative Definition of Sieve	34	0	7

This report has been submitted to letter ballot of the committee, which consists of 41 members, of whom 34 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

L. W. PAGE,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE.

The proposed revision in the Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment referred to in this report was accepted for publication in the Proceedings.

The two proposed tentative tests and the four proposed tentative definitions referred to in the report were accepted for publication among the Tentative Standards of the Society, and appear on pages 773–777 and 837.

APPENDIX I.

PROPOSED TENTATIVE REVISION

OF

STANDARD METHOD FOR DISTILLATION OF BITUMINOUS MATERIALS SUITABLE FOR ROAD TREATMENT (D 20-16).[1]

Strike out the present Section 3 (*b*), namely:

"(*b*) *Thermometer*—(1) The thermometer shall be made of resistance glass (Jena 59 . . . Jena 19 . . . Verra dur are suggested); (2) it shall be filled with CO_2 under pressure of one atmosphere at 300° C., and shall be provided with expansion bulb at the top; (3) it shall be annealed at 400° C. for 96 hours and slowly cooled; (4) it shall be graduated in single degrees Centigrade from $-5°$ C to $+400°$ C.; (5) the length of the graduations from 0 to 400° C. shall be 300 mm. (± 10 mm); (6) the diameter of stem shall be 7 mm. (± 1 mm.); (7) when the thermometer is at a temperature of 26° C., and plunged into a free flow of steam, the meniscus shall pass the 90° mark in not less than 6 seconds.

"The thermometer shall be set up as for the distillation test, using water, naphthalene and benzophenone as distilling liquids. The correctness of the thermometer shall be checked at 0 and 100° C. after each third distillation until seasoned.",

and insert the following:

"(*b*) *Thermometer.*—The thermometer shall conform to the following requirements:

"It shall be made of thermometric glass of a quality equivalent to suitable grades of Jena or Corning make. It shall be thoroughly annealed. It shall be filled above the mercury with inert gas which will not act chemically on or contaminate the mercury. The pressure of the gas shall be sufficient to prevent separation of the mercury column at all temperatures of the scale. There shall be a reservoir above the final graduation large enough so that the pressure will not become excessive at the highest temperature. The thermometer shall be finished at the top with a small glass ring or button suitable for attaching a tag. Each thermometer shall have for identification the maker's name, a serial number, and the letters 'A.S.T.M. Distillation.'

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[1] 1916 Book of A.S.T.M. Standards, p. 540.

"The thermometer shall be graduated from 0 to 400° C. at intervals of 1° C. Every fifth graduation shall be longer than the intermediate ones, and every tenth graduation beginning at zero shall be numbered. The graduation marks and numbers shall be clear-cut and distinct.

"The thermometer shall conform to the following dimensions:

Total length, maximum......	385 mm.	
Diameter of stem...........	7 "	; permissible variation, 0.5 mm.
Diameter of bulb, minimum..	5 "	; and shall not exceed diameter of stem.
Length of bulb.............	12.5 "	permissible variation, 2.5 mm.
Distance from 0° to bottom of bulb....................	30 "	; " " 5 "
Distance from 0° to 400°....	295 "	; " " 10 "

"The accuracy of the thermometer when delivered to the purchaser shall be such that when tested at full immersion the maximum error from 0 to 200° C. shall not exceed the following:

From 0 to 200° C..................................	0°.5 C.
" 200 " 300° C..................................	1°.0 C.
" 300 " 375° C..................................	1°.5 C.

"The sensitiveness of the thermometer shall be such that when cooled to a temperature of 74° C. below the boiling point of water at the barometric pressure, at the time of test, and plunged into free flow of steam, the meniscus shall pass the point 10° C. below the boiling point of water in not more than 6 seconds.

"The thermometer shall be set up as for the distillation test, using water, naphthalene and benzophenone as distilling liquids. The correctness of the thermometer shall be checked at 0 and 100° C. after each third distillation until seasoned."

APPENDIX II.

REPORT

ON

BRITISH STANDARD NOMENCLATURE OF BITUMINOUS MATERIALS.

During the past year Report No. 76 of The Engineering Standards Committee upon "British Standard Nomenclature of Tars, Pitches, Bitumens and Asphalts," together with certain letters from Col. R. E. Crompton and Mr. Clifford Richardson relating to this report, were referred to Committee D-4 for consideration and such action as it deemed advisable. Committee D-4 therefore submits certain comments regarding these matters as a part of its report for 1917.

Before presenting its own comments and conclusions, it has been considered advisable by Committee D-4 to set forth the definitions adopted by the Engineering Standards Committee, together with the Introductory Remarks of the report and such portions of the letters above mentioned as are pertinent to the subject.

I. DEFINITIONS ADOPTED BY THE ENGINEERING STANDARDS COMMITTEE.

First Group; Tar Products (Principally Coal Tar and Pitch).

1. *Tar.*—Tar is the matter (freed from water) condensed from the volatile products of the destructive distillation of hydrocarbon matter, whether this be contained in coal, wood, peat, oil, etc.

2. *Prefix denoting source of origin or method of production.*—A prefix such as coal, wood, peat, gas-works, blast-furnace, coke-oven, etc., must be added to the word "tar" to indicated the source of origin or method of production.

3. *Pitch.*—Pitch is the solid or semi-solid residue from the partial evaporation or distillation of tar.

SECOND GROUP; BITUMENS AND ASPHALTS.

4. *Bitumen.*—Bitumen is a generic term for a group of hydrocarbon products soluble in carbon disulfide, which either occur in nature or are obtained by the evaporation of asphaltic oils. The term shall not include residues from paraffin oils or coal tar products.

NOTE.—Commercial materials may be described as bitumen if they contain not less than 98 per cent of pure bitumen as defined above.

5. *Native Bitumen.*—Native bitumen is bitumen found in nature, carrying in suspension a variable proportion of mineral matter.

The term "native bitumen" shall not be applied to the residuals from the distillation of asphaltic oils.

6. *Asphalt.*—Asphalt is a road material consisting of a mixture of bitumen and finely graded mineral matter. The mineral matter may range from an impalpable powder up to material of such a size as will pass through a sieve having square holes of $\frac{1}{4}$-in. side.

7. *Native or Rock Asphalt.*—Native or rock asphalt is a rock which has been impregnated by nature with bitumen.

8. *Prefixes denoting Source of Origin.*—The committee recommends that for convenience of identification prefixes denoting geographically the source of origin should be attached to each of the four terms in this group.

II. INTRODUCTORY REMARKS OF THE ENGINEERING STANDARDS COMMITTEE.

The materials now used by road engineers for binding together the stones and other mineral aggregate used to form road crusts and road surfaces may be conveniently divided into three groups. These are:

1. The tars and pitches obtained by the destructive distillation of coal or similar substances;

2. The bitumens and asphalts which are found in nature, or are obtained artificially from asphaltic oils; and

3. Chemical binders, including the Portland and natural cements, which owe their cementing value as road binders to chemical action, and which are not dealt with in the present report.

Hitherto the term "bituminous material" has been loosely applied to tar products as well as bitumens and asphalts, but the committee have from the first considered that it was desirable from the road engineers' point of view to maintain a sharp line of demarcation between the two groups. The views put forward in correspondence from America, and by American engineers of standing and experience, have been carefully considered, but the committee still adhere strongly to the view that the description "bituminous" should be applied only to the second group.

In this country the first group of road binders, the coal tars and pitches have been in use for many years, and as the Road Board in 1911 issued specifications for the tars, tar oils and pitches, which they recommend for road purposes, these materials have already to some extent been defined by those specifications. The Road Board early in 1914 issued a second edition of these specifications. Only two classes of tar, and one class of pitch, are dealt with, and as these specifications are of such recent date, the committee recommends that they be adopted provisionally as the British Standard Specifications for Tars and Pitches used for Road Work.

The committee find that the choice of names for the second group of binders is a matter of some difficulty. This difficulty is increased by the fact, that while it is desirable to obtain the concurrence of the American engineers to the nomenclature and definitions which the committee now propose, the adoption of the American nomenclature for the various materials composing this group would be liable to lead to confusion and misunderstanding in this country.

The committee have been very anxious to secure uniformity with American practice, and have carefully and fully considered the definitions adopted by the American Society for Testing Materials and by the committee of the American Society of Civil Engineers, put forward by the American corresponding members, but it is felt that the definitions now decided on are preferable from the road engineers' point of view, as they are based on those characteristics of the materials which can be most readily verified when employed for road making.

In accordance with this view the committee consider that it is desirable to make a sharp distinction between coal-tar and paraffin-oil derivatives on the one side, and native bituminous substances and asphaltic-oil residues on the other, and they are therefore unable to accept the American definition of bitumen which would include the coal tars.

III. EXCERPTS FROM LETTER OF COL. R. E. CROMPTON.

"I was chairman of that committee; the deliberations have occupied two years. As you know, we had the assistance of two American engineers, but we, for obvious reasons, were unable to agree to the American custom of classing bitumens and tars together, which has led to a considerable amount of fraud and great disappointment in this country; for the difference between a pitch derived from a coal tar and a bitumen derived from a distillation of asphaltic oil is so great and so radical, that it involves questions of success or failure in road construction. You may judge of the desire of unscrupulous people on this side to confound the two materials when I tell you that the price of coal tar pitch is now about 30 shillings a ton, whereas that of the best Mexican oil bitumen such as that from Messrs. Pearson's oil wells, or from other wells of the same district, is about 150 shillings a ton, or 5 to 1, but you will be glad to know that our report has absolutely stopped the sale of a pitch costing 30 shillings with about 5 per cent of bitumen added to it and sold as somebody's patent bitumen at 80 shillings a ton, which was a very common procedure up to quite a recent date."

IV. LETTER FROM MR. CLIFFORD RICHARDSON.

"I am desirous of bringing to your attention the conclusions of the British Engineering Standards Committee as regards a definition of bitumen, and am sending you some excerpts from a recent number of the *Surveyor* on the subject, which are of interest."

The excerpts to which reference is made in Mr. Richardson's letter are a reprint of the Introductory Remarks previously given and the following from the *Surveyor*, June 2, 1916, under the heading "Things One Would Like to Know:"

Are not the Engineering Standards Committee to be congratulated on the excellent report that they have at last published upon the much disputed question as to the proper manufacture[1] of tars, pitches, bitumens and asphalts, when used for road purposes? Is it not to be hoped that our American cousins will fall into line and cease to call certain groups of tar products "bitumens?" Has not the steady and reliable work of this committee for some years past been of enormous value to this country, and a great help both to engineers and manufacturers?

(NOTE.—This information was sent by Mr. Richardson to Secretary-Treasurer Marburg with a statement that Mr. Richardson has always held that the definition of bitumen proposed by Committee D-4 is open to serious criticism. Mr. Marburg suggested that the matter be referred to Mr. Page.)

With regard to these data, Committee D-4 reports as follows:

1. It is evident that the basic difference between the British and American nomenclature has to do with the term bitumen. The standard definition of the Society includes all mixtures of native or pyrogenous hydrocarbons and their non-metallic derivatives which are soluble in carbon disulfide. It thus includes the carbon-disulfide-soluble constituents of tars as well as of petroleums and asphalts The British definition eliminates tars by including only native hydrocarbon products or those obtained by the evaporation of asphaltic oils. In this respect it coincides with Mr. Richardson's ideas.

Before discussing this basic difference, attention is called to an important inconsistency in the British definition. An attempt has been made not only to eliminate the principal tar hydrocarbons, but also certain paraffin hydrocarbons. Thus it is stated that "the term shall not include residues from paraffin oils." The wording of the definition, however, by covering "a group of hydrocarbon products soluble in carbon disulfide, which occur in nature," would include crude paraffin petroleums, unless an exceedingly obscure and indefinite meaning is attached to the phrase "a group," such as "a certain specific group," in which case the definition would be so vague as to be almost meaningless. It is thus seen that a strict interpretation of the definition would include paraffin petroleums but would exclude residues from paraffin petroleums.

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[1] Evidently a misprint and meant for "nomenclature."

The American definition is sufficiently broad to make it perfectly possible to determine the actual percentage of bitumen in bituminous materials, while the British definition is absolutely valueless in this respect. For example, the British definition, while including a refined native asphalt fluxed with an asphaltic-petroleum residuum, would exclude, so far as analytical methods of determination are concerned, the same asphalt fluxed with a paraffin or semi-asphaltic flux. In this respect it would most certainly not conform with our understanding of Mr. Richardson's ideas.

With regard to the elimination of tar hydrocarbons: while the trade reasons advanced by Colonel Crompton may apply to the British market, they certainly carry no weight in this country, and we believe that if the American definition of bitumen, together with the subsidiary American nomenclature, had been adopted by the Engineering Standards Committee, misunderstandings such as Colonel Crompton mentions would have been avoided. In its introductory remarks, the Engineering Standards Committee states that "Hitherto the term 'bituminous materials' has been loosely applied to tar products as well as to bitumens and asphalts, . . . but the committee still adhere strongly to the view that the description 'bituminous' should be applied only to the second group." If precedent is to be considered at all, we would bring to attention the use of the word "bituminous" in connection with coal. Thus the term "bituminous coal" has been used for many years, and it seems but logical to include in the definition for bitumen, those hydrocarbon products derived from bituminous coal which are soluble in carbon disulfide.

The Engineering Standards Committee further state that the definitions which they have adopted "are preferable from the road engineers' point of view, as they are based on those characteristics of the materials which can be most readily verified when employed for road making." Committee D-4 certainly does not agree with this statement as applied to the British definition of bitumen. While it believes with the British committee that it is desirable to make a distinction between such products as coal tars, paraffin oils and asphaltic oils, it can see no reason or way to do this under the term bitumen, as it is a well-known fact that certain hydrocarbon products are common to all of these substances, as well as to native asphalts.

To sum up the foregoing discussion: Committee D-4 believes that the British definition of bitumen is much less useful than the definition adopted by the Society, which is definite, consistent, and logical.

2. Committee D-4 has no comment to make upon the British definition of "native bitumen," as the interpretation of the definition is largely dependent upon the meaning of the word "bitumen," which has already been discussed.

3. The British definition of asphalt, aside from its dependence upon the meaning of the word "bitumen" is entirely foreign to the American usage of the term and to the American point of view. This definition coincides with the American idea of a fine-graded bituminous aggregate and includes both the bituminous cement and the mineral particles. It is thus seen in definition No 7 of the Engineering Standards Committee that "native asphalt" is synonymous with "rock asphalt." It should be noted that the latter definition entirely eliminates our oldest and most widely used native asphalts, while the definition of asphalt eliminates all of our oil or petroleum asphalts, and such products as Gilsonite and even refined Bermudez asphalt. The differences are evidently those of long established custom in both countries, and in view of this facts are apparently irreconcilable.

4. The British definition of tar, while worded somewhat differently, is almost the same as the American definition, except that it is not considered to be bitumen, which difference has already been discussed under bitumen. Aside from this, Committee D-4 believes the American definition to be more specific and accurate, inasmuch as it limits the term "tar" to hydrocarbon products produced by destructive distillation which, when subjected to fractional distillation, will yield pitch. It thus eliminates such volatile substances by themselves as ben-

zol, toluol, etc., although these constituents may form a part of the tar.

5. The British definition of pitch is practically the same as the American, except that the former limits the term specifically to semi-solid or solid tar residues, while the latter includes solid residues from any bitumen, but states that the term is usually applied to residues obtained from tars. Committee D-4 believes that there is but little choice between the two, since to all intents and purposes they answer the same purpose. Attention is called, however, to the British lack of distinction between the words "evaporation" and "distillation," which are apparently used synonymously throughout the British nomenclature.

6. Committee D-4 is heartily in accord and strongly indorses recommendations Nos 2 and 8 of the Engineering Standards Committee, regarding the use of prefixes. In fact, as the result of its efforts and recommendations, it might be noted that the Society has even gone to the extent of defining certain classes of bituminous materials as indicated by prefixes suggested by the Engineering Standards Committee.

REPORT OF COMMITTEE D-7
ON
TIMBER.

The report of the committee is devoted to the work of its Sub-Committee on Timber Preservatives. The report of this sub-committee to the main committee is presented below in practically the same form as originally submitted, followed by the recommendations of the committee with respect to matters affecting standards.

SUB-COMMITTEE V ON METHODS OF PRESERVATIVE TREATMENT.

This sub-committee has during the past two years been at work on methods for sampling and analysis of creosote oil. As a result of this work the Tentative Methods for Sampling and Analysis of Creosote Oil (D 38 - 16 T) published in the Proceedings for 1916,[1] have been revised; certain methods are recommended for adoption by letter ballot as standard,[1] and two new ones are recommended for adoption as tentative.

To summarize, Committee D-7 recommends that the following methods, appended to this report[2] under the title proposed Standard Methods for Sampling and Analysis of Creosote Oil, be adopted as standard:

SAMPLING.

Continuous Drip Sample.—This was presented as tentative in 1915 and has been revised as to wording this year, but not changed in substance.

ANALYSIS.

(*A*) *Water.*—This is now presented for the first time as a separate method. The same procedure, however, has been specified, but without the necessary details pertaining to a standard method, in the Distillation Test of the Tentative Methods above referred to.

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[1] Vol. XVI, Part I, p. 564 (1916).

[2] These methods appear in a pamphlet entitled "A.S.T.M. Standards adopted in 1917," supplementary to the 1916 Book of A.S.T.M. Standards.—ED.

(*B*) *Insoluble in Benzol.*—This was presented as tentative in 1916, and has not been revised this year.

(*C*) *Specific Gravity.*—This was presented as tentative in 1915, revised in 1916; wording has been revised this year.

(*D*) *Distillation.*—This was presented as tentative in 1915, revised in 1916, and has been revised again this year.

(*E*) *Specific Gravity of Fractions.*—This was presented as information in the 1916 report of the committee.[1]

The committee further recommends that the following two methods of analysis of creosote oil, appended to this report,[2] be published as tentative:

(*F*) *Float Test of Residue.*—This has not heretofore been presented to the Society. It has been adopted as standard by the American Wood Preservers' Association.

(*G*) *Coke Residue.*—This has not heretofore been presented to the Society. It has been adopted as standard by the American Wood Preservers' Association.

In explanation of the foregoing, it will be noted that the methods recommended for adoption as standard have all been submitted as tentative methods, with the exception of method (*A*), under Analysis, which appeared in the 1916 Proceedings in a different form, and method (*E*) dealing with the specific gravity of fractions, which was presented as information in 1916.

Committee D-7, referring to the Procedure Governing the Adoption of Standards, Article VI of the by-laws of the Society, requests authority from the meeting to include the above two methods in the methods for adoption by letter ballot, in view of the fact that there has been no question as to the eminent desirability of having these clauses incorporated with the other standards. Attention is furthermore called to the fact that these clauses, as well as the remaining clauses in the methods of sampling and analysis recommended this year for adoption as standard, have already been adopted by the American Society of Municipal Improvements and by the American Wood Preservers' Association, following the joint meetings of all committees during the past year.

The two methods, (*F*) and (*G*), recommended for adoption as tentative are self-explanatory.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, pp. 337–338 (1916).

[2] See pp. 826–828.—ED.

Referring to the above recommendations, the committee voted as follows:

1. On recommending for adoption as standard the Methods for Sampling and Analysis of Creosote Oil: Affirmative, 26; negative, 2; not voting, 6.

2. On requesting the meeting to permit methods (*A*) and (*E*), referred to above, by nine-tenths vote, to be included in the standard Methods: Affirmative, 27; negative, 1; not voting, 6.

3. On submitting two methods for adoption as tentative: Affirmative, 28; negative, 0; not voting, 6.

Referring to the proposed tentative specifications for structural Douglas fir bridge and trestle timbers submitted last year, the committee has been at work on this matter in cooperation with members of the United States Forest Service. The Forest Service has this last year made a field study of the application of the proposed density rule to Douglas fir. These data have been analyzed by the members of the Forest Products Laboratory, and up to date they show that the density classification, as suggested last year, should not be applied to Douglas fir in so far as the inspection area was concerned. The trees are of larger size and produce their best wood at a much greater distance from the pith. A new density classification, based on these analyses, is now under consideration and will probably be submitted next year.

On behalf of the other sub-committees, progress is reported.

This report has been submitted to letter ballot of the committee, which consists of 34 members, of whom 25 have voted affirmatively, 1 negatively, and 8 have refrained from voting.[1]

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

EDITORIAL NOTE.

For action taken on this report, see the Summary of Proceedings, pages 25–26.

The proposed Standard Methods for Sampling and Analysis of Creosote Oil referred to in the report were approved at the annual meeting, and subsequently adopted by letter ballot of the Society on August 15, 1917. They appear in a pamphlet entitled "A.S.T.M. Standards adopted in 1917," supplementary to the 1916 Book of A.S.T.M. Standards.

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[1] The vote here recorded was on the report as originally presented, which contained proposed Tentative Specifications for Wooden Paving Blocks, which were referred back to the committee. See p. 25.—ED.

The proposed Tentative Methods for Analysis of Creosote Oil referred to in the report were accepted for publication among the Tentative Standards of the Society, and appear on pages 826–828.

REPORT OF COMMITTEE D-8

ON

WATERPROOFING.

In accordance with the program outlined last year Committee D-8 herewith submits four tentative specifications, namely:

1. Proposed Tentative Specifications for Asphalt for Waterproofing (Type A), for use under uniformly moderate temperature conditions.
2. Proposed Tentative Specifications for Primer for Use with Asphalt for Waterproofing, when specified.
3. Proposed Tentative Specifications for Coal-Tar Pitch for Waterproofing (Type A), for use under uniformly moderate temperature conditions.
4. Proposed Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Waterproofing, when specified.

Because of present conditions, arising from the state of war in which our country is involved, no conclusive work in the matter of conveying media, saturated felts and woven fabrics has been accomplished, and before specifications covering these materials can be drawn up, the questionable part which they actually play in a finished waterproofing membrane must be definitely settled. The present unnatural state of the rag market is another controlling economic feature which at present militates against the preparation of specifications covering media.

In so far as compatible with the more urgent duties of its members, which are increasingly insistent owing to war conditions, the sub-committee in charge of this work will proceed during the coming year with the preparation of specifications for other types of asphalt and coal-tar pitch to be recommended for use under temperature conditions not the most uniform.

The specifications made a part of this report have been submitted to letter ballot of the committee which consists of 26 members, with the following result:

Title.	Affirmative.	Negative.	Not Voting.
Proposed Tentative Specifications for Asphalt for Waterproofing	23	2	1
Proposed Tentative Specifications for Primer for Use with Asphalt for Waterproofing	24	0	2
Proposed Tentative Specifications for Coal-Tar Pitch for Waterproofing	23	0	3
Proposed Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Waterproofing	23	0	3

This report has been submitted to letter ballot of the committee, which consists of 26 members, of whom 21 have voted affirmatively, 1 negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. A. AIKEN,
Chairman.

LEROY M. LAW,
Secretary.

EDITORIAL NOTE.

The four proposed tentative specifications referred to in this report were amended at the annual meeting by substituting for the word "Waterproofing" in the title, the words "Use in Damp-proofing and Waterproofing." The specifications as thus amended were accepted for publication among the Tentative Standards of the Society, and appear on pages 712–722.

REPORT OF COMMITTEE D-9

ON

ELECTRICAL INSULATION.

Committee D-9 herewith submits as its report for the year proposed Tentative Tests for Molded Insulating Materials, appended hereto.[1] These tests were prepared by Sub-Committee II of Committee D-9, were discussed at length in tentative form at a meeting of the committee called for the purpose, and were unanimously agreed to by those present. The proposed tests were subsequently submitted to letter ballot of the committee, which consists of 16 members, of whom 13 have voted affirmatively, 1 negatively, and 2 have refrained from voting.

Committee D-9, on account of the class of specifications it is trying to prepare, has found it very difficult to keep its membership in strict accordance with the requirement that there shall be numeric balance of consumers and producers or a preponderance of the consumer element in the committee. This difficulty arises from the fact that those consumers who maintain suitable laboratories for testing the materials under consideration are largely confined to a few of the larger users who in some instances are also producers of certain classes of materials under consideration. As the committee is devoting itself entirely to the consideration of testing methods and testing apparatus, the committee voted last year to ask the Executive Committee of the Society to waive this requirement in its case, at least until such time as the committee should concern itself with the preparation of specifications for materials, which is not now under contemplation. Through a misunderstanding on the part of the chairman, it was understood that the Executive Committee had granted this request. However, this seems not to be the case. The proposed Tentative Tests for Molded Insulating Materials are nevertheless submitted with the request that since they are tentative, and since they have to do with testing methods and not with the materials themselves, the committee be allowed to present them to the Society in the regular way.

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[1] See pp. 778–790.—Ed.

The committee will take steps to arrange for numeric representation as far as possible in line with the requirements of the Regulations Governing Standing Committees.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 12 have voted affirmatively, none negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. E. SKINNER,
Chairman.

EDITORIAL NOTE.

The proposed tentative tests referred to in this report were accepted for publication among the Tentative Standards of the Society, and appear on pages 778–790.

DISCUSSION.

Mr. H. E. Smith.—In reading the proposed Tentative Tests for Molded Insulating Materials, I notice under "Compressive Strength" that the 1-in. cube is used. I should like to hear some discussion of the reasons for adopting the cube. It is our understanding that the true compressive strength is obtained from a specimen at least 1½ times as tall as it is wide, and preferably a cylinder, the idea being that in the cube the height is so small that the action of the specimen is retarded by the bearing on the two ends. In considerably taller specimens there is sufficient material in the central portion, which is under true compression, so that correct results are obtained. Possibly there is some good reason in this particular kind of material why the cube should be used. **Mr. Smith.**

Mr. C. E. Skinner (*Chairman of Committee D-9*).—There have been arguments both for and against the cube, and the reasons for the adoption of the cube are mainly to provide a test piece which can be tested at 90 deg. from the direction in which it is molded, as this is the weakest plane of this class of material. The letters are put on the face in the direction of molding and consequently the test may always be made at 90 deg., which cannot be done with the cylinder. **Mr. Skinner.**

Mr. Smith.—Could not the specimen be made longer? **Mr. Smith.**

Mr. Skinner.—Yes, it could be made longer. No extensive investigations, however, have been made to determine whether a longer test piece would be more advisable. **Mr. Skinner.**

Mr. W. A. Slater.—If it is necessary that the specimen be tested in a direction at right angles to that in which it was molded, I should like to ask if there is anything that would prohibit the use of a prism whose height is twice its least diameter. **Mr. Slater.**

Mr. Skinner.—There is nothing which would prohibit making the test in that manner. **Mr. Skinner.**

Mr. Slater.—I don't know that that would be as satisfactory as a cylinder, and yet I believe it would be more satisfactory than a cube, for the reasons pointed out by Mr. Smith. **Mr. Slater.**

Mr. Skinner. MR. SKINNER.—I will say, for the committee, that we shall be very glad to consider this suggestion, and I think probably it will be desirable to conduct some comparative tests along this line. This test is more or less empirical, anyhow, and the cube has been used, either rightly or wrongly, by a number of manufacturers for quite a good while, and present data are based on the cube test. We shall be very glad to take these suggestions under advisement.

Mr. Slater. MR. SLATER.—In the same connection, there seems to be a tendency on a number of other committees of this Society to consider the adoption of the specimen whose height is twice its diameter or approximately that, and for the same reason that the cube was mentioned as being desirable in the interest of uniformity with the work of the manufacturer, I believe that it is desirable for the sake of uniformity with the work of the rest of the committees of this Society, that we gradually get over to the other form of specimen in all of our committees, if there is no important reason against it.

REPORT OF COMMITTEE D-10
ON
SHIPPING CONTAINERS.

Committee D-10 has continued to work along lines indicated in last year's report, but national conditions have been such that the necessary investigations by sub-committees, in order to produce data sufficient for the purpose of preparing specifications, have been impossible.

The sub-committee on wooden boxes has prepared Tentative Specifications under the titles Specifications for Canned Foods Boxes, Nailed and Lock Corner Construction, and Specifications for Canned Foods Boxes, Wirebound Construction, covering wooden boxes of nailed, lock corner and wirebound construction for food products in cans, which have been passed upon by the members of Committee D-10 and are herewith presented to the Society for publication as tentative.

This report has been submitted to letter ballot of the committee, which consists of 29 members, of whom 19 have voted affirmatively, none negatively, and 10 have refrained from voting.

Respectfully submitted on behalf of the committee,

B. W. Dunn,
Chairman.

W. S. Topping,
Secretary.

Editorial Note.

The two proposed tentative specifications referred to in this report were accepted for publication among the Tentative Standards of the Society, and appear on pages 723–731.

REPORT OF COMMITTEE D-11

ON

RUBBER PRODUCTS.

Committee D-11 has held one meeting during the past year in addition to meetings of sub-committees. Since the last report seven new members have been added to the membership of the committee, one representing consumers and six producers. Five members have resigned from the committee.

Sub-Committee I on Air Hose.—This sub-committee has presented Tentative Specifications for Air-Line Hose for Pneumatic Tools, which has been referred to letter ballot of the committee which consists of 33 members, of whom 24 have voted affirmatively, 1 negatively, and 8 have refrained from voting. These specifications are appended to this report, and it is recommended that they be published by the Society as tentative.

With reference to air brake and signal hose, the sub-committee reports as follows:

"Air brake and signal hose are a highly specialized product used almost exclusively by railroads.

"At present such hose is manufactured under the Master Car Builders' specifications and it is our understanding that Sub-Committee I is expected to prepare specifications that will be superior to the Master Car Builders' specifications.

"It appears that, due to the interchange of equipment, railroads are practically obliged under Rule 57, M. C. B. Rules of Interchange, to attach hose to their cars that conforms to the M. C. B. standard and which bears the M. C. B. monogram.

"Air brake and signal hose consist of rubber compound and fabric and should specifications be prepared calling for more or better of either of these the cost would inevitably be increased.

"Unless such hose was recognized by the M. C. B. Association equal to or superior to their hose, and its use authorized,

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[1] See pp. 763–766.—Ed.

the situation would be that at interchange points a more expensive and better hose would be removed and a cheaper and poorer hose substituted. Under such circumstances it is doubtful whether any hose would be manufactured under the A.S.T.M. specifications if prepared.

"In the opinion of the sub-committee there is therefore no reason for the Society to prepare such specifications and the sub-committee recommends that they be relieved from further consideration of this subject."

The committee has considered the above suggestions, but has decided to hold the matter in abeyance until the members have had an opportunity to familiarize themselves with the specifications of the Master Car Builders' Association, so that they will be in a better position to reach a wise decision.

Sub-Committee II on Belting.—This sub-committee has been considering specifications for belting but can report only progress at this time.

Sub-Committee III on Cold-Water Hose.—Specifications for Rubber-Covered Hose have been under consideration but are not yet ready for presentation. The sub-committee has also had under consideration a few changes in the specifications on Cotton Rubber-Lined Hose which were suggested by the Manufacturers' Sub-Committee with a view to the standardization of specifications for these products. No final action has been taken on this matter as yet.

Sub-Committee V on Insulated Wire.—A number of matters concerning the specifications have been under consideration but are not yet ready to be reported upon.

Sub-Committee VI on Packing, Gaskets and Pump Valves.—A number of tests on pump valves have been conducted, but the sub-committee is not prepared to make any definite report as yet.

Sub-Committee VII on Steam Hose.—This sub-committee presented specifications for steam hose for the consideration of the committee, but they were referred back to the sub-committee with suggestions for a number of changes.

Sub-Committee VIII on Definitions.—Committee D-11 has requested this sub-committee to formulate and report definitions for such technical terms as are now used in the specifications which have been drawn up by the committee.

Sub-Committee IX on Rubber Insulating Tape.—This subcommittee has nothing to report but progress.

This report has been submitted to letter ballot of the committee, which consists of 33 members, of whom 24 have voted affirmatively, 1 negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

EDW. A. BARRIER,
Chairman.

F. M. WARING,
Secretary.

EDITORIAL NOTE.

The proposed tentative specifications referred to in this report were accepted for publication among the Tentative Standards of the Society, and appear on pages 763–766.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS.

Since the last annual meeting of the Society, it has not seemed necessary, in the midst of such active engagements throughout the country, to hold a special meeting of Committee D-13 until advantage could be taken of the expected Annual Conference of Textile Industries before the Bureau of Standards in Washington, which was first called for the last week in April. Owing, however, to conflict of this date with the meeting of the National Association of Cotton Manufacturers in Boston, this Conference was deferred until May 21, 1917, when a meeting of the committee was held at which 19 members or representatives of members of the committee, and 12 guests, not members, were present. A previous poll of the membership had indicated that very little change, if any, was desired by those who had taken the most interest in the past year's experience with testing. The purpose of this meeting, therefore, was to determine what ought to be added to or subtracted from the Tentative General Methods for Testing Cotton Fabrics and those specific Tentative Tests which had been in use during the past year.[1]

As a result much interesting discussion was followed by a vote endorsing the proposition to retain as tentative the specific methods as adopted for another year.

It was also voted that the chair appoint a sub-committee of three members:

"To consider suggestions made by members at this meeting and report with recommendations to the general committee from time to time during the year."

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[1] The methods and tests referred to are published in the *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I (1916), as follows: Tentative Methods for Testing Cotton Fabrics (D 39–16 T), p. 572; Tentative Tests for Automobile Tire Fabrics (D 31–16 T), p. 531; Tentative Tests for Cotton Fabrics for Use in Hose, Belting and Similar Articles (D 32–16 T), p. 533; and Tentative Tests for Cotton Fabrics for Use in Bags and Bagging Material (D 33–16 T), p. 534. See also among the Tentative Standards in this volume.—Ed.

The chair appointed upon this committee:

Mr. A. H. Clarke, *Chairman*, representing Bemis Bros. Bag Co.;
Mr. Kenneth Moller;
Mr. A E. Jury, representing the United States Rubber Co.

Upon motion also a second sub-committee was appointed consisting of five members and three non-members

"To investigate ways and means of harmonizing methods of testing fabrics in the cotton industry throughout the country and to seek means of publicity."

The chair appointed on this committee:

Dr. S. W. Stratton, of the Bureau of Standards, *Chairman;*
Professor G. B. Haven, Massachusetts Institute of Technology;
Dr. A. A. Somerville, of the United States Rubber Co.;
Mr. D. E. Douty, of the United States Conditioning & Testing Co.;
Mr. H. V. R. Scheel (or his representative), Brighton Mills, Passaic, N. J.,

together with three other persons not members. This sub-committee was given power to add to their number from time to time.

This report has been submitted to letter ballot of the committee, which consists of 36 members, of whom 23 have voted affirmatively, 1 negatively, and 12 have refrained from voting.

Respectfully submitted on behalf of the committee,

WM. D. HARTSHORNE,
Chairman.

REPORT OF COMMITTEE E-1

ON

METHODS OF TESTING.

Committee E-1 has held two meetings since the annual meeting of the Society in June, 1916.

At the meeting of March 16, 1917, the sub-committee on "The Effect of Speed of the Testing Machine on the Determination of the Yield Point and Tensile Strength of Materials," of which Mr. T. D. Lynch is chairman, presented a final report.

This report was adopted at the meeting and subsequently by letter ballot of the committee.

A progress report was presented by Prof. H. F. Moore, chairman of the sub-committee on "Effect of Form and Size of Test Piece." This progress report is appended hereto for the purpose of inviting discussion.

Two other sub-committees reported progress.

Committee E-1 recommends that the following changes in the Standard Methods for Testing (Serial Designation: E 1–16)[1] be published by the Society as tentative with the object of adopting them as standard next year. They are merely the changes necessary to make the Standard Methods harmonize with the report adopted by Committee E-1 on the effect of speed of the testing machine, referred to above.

Proposed Revisions of the Standard Methods for Testing (E 1–16).

1. *Section 5.*—Change from its present form, namely:

> "5. All information obtained confirms the investigations of Committee O (since dissolved), to the effect that within the limits of speed common in commercial testing, the effect of different speeds on results is not of observable moment; that is, within ranges of speed varying from 1 to 6 in. per minute.",

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[1] 1916 Book of A.S.T.M. Standards, p. 602.

to read:

"5. The pulling speed has a marked influence on the tensile properties shown by materials tested, an increase in speed increasing the values found for yield point and tensile strength. In testing steel and wrought iron in gage lengths of 2 and 8 in. in accordance with the specifications of the American Society for Testing Materials, the speed of the machine, by which is meant the speed of the crosshead when the machine is running idle, shall conform to the following requirements:

"The crosshead speed of the testing machine shall be such that the beam of the machine can be kept balanced, but in no case shall the values given in the following table be exceeded:

Specified Minimum Tensile Strength of Material, lb. per sq. in.	Gage Length, in.	Maximum Crosshead Speed for Testing Machine in Determining, in. per minute.	
		Yield Point.	Tensile Strength.
80 000 or under.........	2	0.50	2.0
	8	2.00	6.0
ver 80 000............	2	0.25	1.0
	8	0.50	2.0

2. *Section 6.*—Change from its present form, namely:

"6. Beyond these limits, however, very rapid loading influences the ultimate strength, which increases with the speed. Whether the elongation is increased or decreased depends somewhat upon the nature of the material, though in general, very rapidly applied loads will increase the stretch, owing to the elongation occurring over the whole body of the specimen, rather than chiefly at the point of reduction, which is more marked with slowly applied loads.",

to read:

"6. In determining the elastic limit (so-called) by the method prescribed in the American Society for Testing Materials Specifications for forgings and cold-rolled axles

(Serial Designations: A 18, A 19, A 63 and A 22),[1] the crosshead speed for the 2-in. gage length shall not exceed 0.12 in. per minute."

Section 7.—Change from its present form, namely:

> "7. Within the limits of speed customary in determining the modulus of elasticity, it does not appear that the rate of loading influences the value obtained, but whether this value be determined by an autographic attachment to the machine, or by an extensometer on the specimen, it is desirable that the loading be not too rapid, or not over 0.05 in. per minute, to avoid impairing the accuracy of the sensitive devices employed.",

to read:

> "7. In determining the proportional limit, the crosshead speed shall not exceed 0.025 in. per inch of gage length per minute."

This report has been submitted to letter ballot of the committee, which consists of 31 members, of whom 23 have voted affirmatively, none negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

GAETANO LANZA,
Chairman.

EDITORIAL NOTE.

The tentative revisions of the Standard Methods for Testing proposed in this report were accepted for publication in the Proceedings.

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[1] See 1916 Book of A.S.T.M. Standards.

APPENDIX.

REPORT OF SUB-COMMITTEE
ON
EFFECT OF FORM AND SIZE OF TEST PIECE.

This sub-committee of Committee E-1 was formed in the autumn of 1916 and has spent its time in outlining the problem set before it and in starting work on one phase of that problem.

The problem as it presents itself to the sub-committee may be summarized as follows:

The results of tension tests of specimens are affected to some extent by the form and size of the test piece; especially is the elongation at rupture affected. Considerable experimental study has been given to the effect of form and size of test piece, especially by foreign testing laboratories, and standard proportions for test pieces have been proposed. The short tension test pieces used in American practice differ from the forms of specimens used abroad, and it is desirable to correlate, if possible, the results of tension tests made on these short specimens with the results of tension tests on longer specimens.

The proposed work of the sub-committee may be divided into two parts: (1) A study of available literature and test data to determine as far as possible from tests already made what relation exists between test results for different sizes and shapes of specimens, and (2) such tests as may be found necessary to supply information not found in available literature or test data.

The first part of the program is already under way.[1] Reports from the various members of the sub-committee are due

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[1] The following literature is known to have bearing on the subject: Bauschinger's "Mittheilungen"; Martens' "Handbook of Testing Materials"; Unwin's "Testing of the Materials of Construction"; Bach's "Elastizität und Festigkeit"; Wawrziniok's "Handbuch des Material Prünfungswesens"; Report of the French Commission of Testing Materials. In addition there are available data from several American testing laboratories.

April 1, 1917, and by May 1 the chairman hopes to have a summary of these reports ready for approval by the sub-committee. It is hoped that the report on the available data on effect of form and size of test piece may be presented to Committee E-1 at the time of the next annual meeting of the Society, and that a plan of experimental work may be laid out by that time.

Respectfully submitted on behalf of the sub-committee,

H. F. MOORE,
Chairman.

REPORT OF COMMITTEE E-3

ON

REVISION OF PIPE THREADS.

Forming part of a Joint Committee on this subject with Committees of the following Societies:

American Gas Institute.
American Society of Mechanical Engineers.
Manufacturers' Association on Standardization of Fittings.
Master Car Builders' Association.
Railway Signal Association.

Following the annual meeting in Atlantic City in 1916, a meeting of the committee was held on June 29, at which time no formal action was taken on the proposed changes in pipe threads, but the consensus of opinion was that the U. S. Standard thread was a better thread than the Briggs standard. A sub-committee was appointed to recommend tolerances and gages for pipe threads on this basis.

Some valuable data were developed by work done on the Briggs thread for the Crane Co. These points are as follows:

1. That the flat allowed on the standard Briggs thread is much sharper than is practical for cutting commercial threads, this being especially true of male threads.

2. When such a male thread is gaged by a ring gage having a true Briggs thread, the sharp crests of the Briggs thread will bear on the rounded bottom of the commercial male thread, thereby giving a false gaging for the pitch diameter, and a pipe so threaded will enter the fitting too loosely.

3. To facilitate gaging this commercial male thread, it is suggested that the sharp crests of the thread on a gage be lightly removed. The amount to be removed should be four times the flat allowed by the Briggs formula in the case of female ring gages, and twice the flat on the crests of the male or plug gage. The bottom of the threads on both gages should retain the true Briggs shape.

4. To properly gage the flattening of the crests of the proposed modified form of thread, a tapered blank plug is sug-

gested for determining this dimension on female threads of fittings and a tapered blank ring for similar determination on the male threads for pipe nipples, etc.

Laboratory tests have been conducted to compare the Standard Briggs thread with the proposed modification. These tests include comparisons of the resistance to leakage under air and hydraulic pressures. Drop tests were made to compare the resistance of the two types to impact and shock, using threaded specimens. Tensile tests were made to determine resistance to stripping of the two types. Bend tests were made to compare the strength of a threaded section of pipe and to study the effects of the modifications. These tests resulted in establishing the following facts:

1. The proposed thread shows a little better results under both the air and hydraulic tests.

2. In the tensile and drop tests the proposed thread shows about one-third as many breakages as the existing standard.

3. The bend test was not very satisfactory.

4. From the foregoing results the conclusion is drawn that in the case of smaller size pipes up to 1 in., there is little difference in the strength of the connection to resist service conditions; but for the larger sizes of pipe the additional metal at the root of the proposed thread increases the ability of the pipe to resist bending or shock stresses.

In addition to the first series of laboratory tests a second series of tests have been conducted to confirm the previous tests. These tests, however, were made with samples prepared by using carefully selected pipe fittings that had been inspected and gaged to insure as nearly as possible uniform test conditions. All these fittings had the standard Briggs threads. In the pressure, drop and tensile tests, malleable and rolled sleeves and ells were used. The air pressure tests were made with samples submerged in water. These test sections were all made up of standard weight and extra heavy pipe, alternate connections in each having the proposed threads. All the connections were made with oiled threads having first been cleaned with gasoline and then carefully oiled. The summary of the results of these laboratory tests indicates that under air pressure the proposed thread on both the stock and the inspected fittings show a little better results than the standard thread, while under hydraulic pressure the standard threads show up a little better. In either case the laboratory results show a difference that is not very great, and the two types of thread may be regarded as practically equal in this respect.

These laboratory results, however, are not confirmed by the results of a road test conducted on 24 locomotives. On these road tests, the proposed threads showed about 28 per cent more leaks per locomotive month than the standard thread; in the drop test and tensile test the pipe for the proposed threads showed only 44 per cent as many failures as the standard thread, which indicated that the strength of the pipe to resist bending and vibration will be increased by using this proposed thread, which provides additional metal at the root. The road service tests were conducted with 12 locomotives fitted with the standard thread and 12 locomotives with the proposed thread. The pipe sizes used were from $\frac{3}{8}$ to $1\frac{1}{2}$ in. All connections were made with the application of approximately the same force in all cases. Weekly inspections were made to observe leaks. Records were kept of leaks, also of all renewals of pipes and fittings for any cause. A number of leaks observed in the couplings of the proposed thread during the first part of the trial indicate that these connections were not tightened with sufficient force and also that extra force is necessary to crush the top of the thread in the fittings in order to allow the slopes of the threads to come in contact and form a tight joint. After this trial above outlined, additional engines were placed in service with fittings carefully inspected and gaged to insure uniform conditions. The results of these service tests indicate about 28 per cent more leaks per locomotive month with the proposed thread than with the standard thread. On the other hand the pipe with the proposed thread had had only about 69 per cent as many renewals as pipes with standard thread, removals and renewals being necessary on account of re-applying auxiliary devices, etc.

At the last meeting of the committee the conclusion was reached and a formal motion made and unanimously adopted to the effect that the form of the U. S. standard thread was a better type than the present Briggs standard, and that it would be advisable to replace the Briggs thread with the U. S. standard by gradual changes over a period of years. For the present, the tolerances are not to exceed the U. S. or be less than the Briggs; this will preserve all of the principal features of the Briggs standard, except that the top and bottom of the threads will be flattened a little more than at present.

In accordance with the direction of the Executive Committee, the subject matter in the foregoing report was presented to Committee A-1 on Steel.

This report has been submitted to letter ballot of the committee, which consists of 9 members, of whom 7 have voted affirmatively, none negatively and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. V. WILLE,
Chairman.

EDITORIAL NOTE.

For action taken on this report see the Summary of Proceedings, page 16.

REPORT OF COMMITTEE E-4

ON

MAGNIFICATION SCALES FOR MICROGRAPHS.

Committee E-4 was organized and held one meeting during the year, at which 12 members were present or represented, and 2 unavoidably absent. Since this meeting one new member has been elected.

A sub-committee was appointed to formulate definitions, and their report was received and accepted by letter ballot.

The committee has prepared the appended Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys, and offers them for adoption by the Society as tentative, with the request that the Secretary-Treasurer of the Society submit them to other societies, both in this country and abroad, with a view of securing their criticism and cooperation.

This report has been submitted to letter ballot of the committee, which consists of 15 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. Bassett,
Chairman.

Editorial Note.

The proposed tentative definitions and rules referred to in this report were accepted for publication among the Tentative Standards of the Society, and appear on pages 838–841.

DISCUSSION.

Mr. Comstock.

MR. GEORGE F. COMSTOCK (*presented in written form and read by the Secretary*).—The general idea and form of the tentative standard magnifications for micrographs of metals and alloys are without doubt excellent, but the writer desires to place on record certain objections to the values proposed as standard.

These values should be so chosen, and sufficiently numerous, as to be capable of giving the best results with every good, practical form of apparatus. The writer uses a Leitz outfit, exactly as supplied by the manufacturer, and his experience, based on several years' critical use of this apparatus, has led to the adoption of 20, 50, 100, 200, and 400 diameters as standard magnifications. With these magnifications it is believed the best use can be made of the lenses supplied by E. Leitz & Co., so as to get good definition covering on a $3\frac{1}{4}$ by $4\frac{1}{4}$-in. plate the largest practical circular or rectangular area. For instance, to get a magnification of 150 diameters, the writer could use either (1) the lenses used normally for 100 diameters, with a longer camera extension, but at a loss of definition and actual area of field of view covered by the plate; or (2) the lenses used normally for 200 diameters, with a shorter camera extension, which, however, would give a field not covering the entire $3\frac{1}{4}$ by $4\frac{1}{4}$-in. plate as well as 200 diameters would cover it. Furthermore, a magnification of 250 diameters gives much poorer results in definition with the writer's apparatus than one of 200 diameters gives; and likewise 500 diameters give much poorer results than 400 diameters, and the gain in magnification is entirely neutralized by the loss in definition with the lenses which must be used in the writer's outfit.

It is not clear why separate standards should be necessary or advisable for ferrous and non-ferrous materials. Aluminum bronze and manganese bronze are much like steel in microstructure, and good magnifications for one should be equally good for the other.

The specification of 75 diameters as standard for showing

Mr. Comstock. the grain size of copper and copper alloys was evidently made with a consideration only of rolled material. Such a magnification of cast pure copper, or of cast 30-per-cent brass, or of cast 7-per-cent aluminum bronze, would give no idea of the grain size on a $3\frac{1}{4}$ by $4\frac{1}{4}$-in. plate, for only portions of a few normal grains could be shown. Twenty diameters is a suitable magnification to show the grain size of all cast non-ferrous alloys; and in castings of a duplex structure, the crystallin structure within the grains is generally shown best by magnifications of 100 or 200 diameters, and eutectics or eutectoids best by 400 diameters.

The phrase "for general use in Society reports" occurring both in Sections 2 (*b*) and 3 (*b*) should certainly not be understood to prevent the use of higher or lower magnifications in these reports when such magnifications are necessary to show properly certain structures.

Finally, would it not be well to amplify the idea expressed in Section 4 (*c*), and to mention certain standard sizes for round and rectangular prints of micrographs?

Mr. Mathews. Mr. J. A. Mathews (*by letter*).—In reference to the report of Committee E-4 on Magnification Scales for Micrographs, I should like to say that our laboratory (Halcomb Steel Co.) was the first to call the attention of any society to the necessity of this standardization, in a paper presented at the Congress of The International Association for Testing Materials in New York, in 1912. We think that the outline submitted by Committee E-4 is in general satisfactory, but would offer a few suggestions.

In Section 2 (*a*), we believe that the standard magnifications for steel should also include 1000 and even 1500. These high magnifications are very desirable, and even necessary, in the work on hardened steels of extremely fine structures.

In reference to Section 4 (*c*), we believe that round photographs are preferable to square ones, even though they do not economize space quite so well. Of two prints from the same negative, one square and the other round, both of the same diameter, the round print always appears to the best advantage due to the more uniform definition falling off gradually from

Mr. Mathews.

the center to the outside, while in the case of the square pictures the lack of definition of the corners is more noticeable. This is especially true in magnifications of 500 diameters and upward. We prefer round pictures, and suggest a diameter of 3 in. for use in reproduction, and for our own work and permanent files we make use of a $3\frac{1}{2}$-in. round print.

REPORT OF COMMITTEE E-5

ON

STANDING COMMITTEES.

THIS COMMITTEE CONSISTS OF THE CHAIRMEN OF ALL STANDING COMMITTEES, OR REPRESENTATIVES DESIGNATED BY THE RESPECTIVE CHAIRMEN. THE DUTIES OF THIS COMMITTEE ARE THE FORMULATION OF (*a*) REGULATIONS GOVERNING STANDING COMMITTEES, (*b*) REGULATIONS GOVERNING THE FORM BUT NOT THE SUBSTANCE OF STANDARDS, AND (*c*) THE CLASSIFICATION OF STANDARDS.

Since the last annual meeting of the Society, Committee E-5 has held three well-attended meetings, one in October, 1916, one in December, 1916, and the third in March, 1917. At the invitation of the chairman these three meetings were also attended by the President of the Society. The work of the committee for the year may be summarized as follows:

Regulations Governing Standing Committees.—Amendments have been made to the "Note" following the title of the Regulations Governing Standing Committees as well as to the following sections of the Regulations; Appointments, paragraph 3; Permanent Organization; Proxies; Sub-Committees; and Reports. These changes are all indicated in Appendix I to this report. They were also announced to the membership at large in Circular No. 113 issued in November, 1916, and in Circular No. 116 issued in April, 1917. All of the changes, except that relating to Appointments, were made prior to the publication of the 1916 book of A.S.T.M. Standards, so that these sections appear in that volume in their latest revised form. The foregoing changes in the regulations were all taken up either at the initiative of Committee E-5 or in pursuance of instructions from the Executive Committee and they have all been approved by the Executive Committee.

Proposed Plan for Holding Committee Meetings.—Committee E-5 has given consideration during the past year to the formulation of a plan by which meetings of committees whose work lies in cognate fields may be held during a given period in the same city, with a view of minimizing expense and loss of time to members holding membership on different committees. In the judgment of the committee such a plan would be practicable to only a limited extent, and its adoption within such limits should be left to the independent judgment of the committees concerned. The committee, however, presents herewith a summarized analysis in tabular form of the personnel of the various standing committees (as of May 1, 1917) in its bearing on the question of overlapping of membership; and also desires to make the following recommendations to the standing committees:

1. To arrange for meetings of their own committees and of other committees in which their own members are largely represented in whatever way may seem most advantageous;

2. That each secretary advise the secretaries of other committees having members in common with his own committee, of the dates of the meetings of his committee as soon as these dates have been determined;

3. That the committees be encouraged to hold their meetings on fixed dates and that these dates be published in the membership pamphlet and the book of A.S.T.M. Standards in connection with each committee and also in summarized form.

Classification of Standing Committees and Standards.—Suggestions to the effect that it was desirable to reconsider the present method of classifying Standing Committees and Standards were made by members of Committee E-5, and in order that this question might be given thorough consideration, a sub-committee of three was appointed in the fall of 1915. This sub-committee, after careful consideration of the subject, recommended radical changes in the present classification. The report of this sub-committee was thoroughly canvassed at the three meetings of Committee E-5 held during the past year. After very thorough consideration, it was finally decided by Committee E-5 that no essential change should be made in the present scheme of classification, which provides that the title of a committee or standard shall be preceded by a prefix of a letter indicating the general classification of the subject and a number assigned to the specific committee or standard, with the

TABLE SHOWING OVERLAPPING OF MEMBERSHIP OF STANDING COMMITTEES AS OF MAY 1, 1917.

Committee....		A-1	A-2	A-3	A-4	A-5	A-6	B-1	B-2	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	D-9	D-10	D-11	D-13	E-1	E-2	E-3	E-4	E-5	E-6	E-7
⋮	Total Membership.	110	38	45	11	42	11	10	41	52	12	14	20	11	16	15	28	22	16	29	88	21	4	40	28	16	35	26	16	28	34	33	31	3	10	15	35	9	7
A-1....	110	...	17	7	6	15	3	3	11	6	4	...	1	1	...	1	...	1	...	...	9	2	...	1	3	2	2	1	1	2	7	...	16	1	5	4	9	3	...
A-2....	38	17	...	3	1	4	...	...	4	2	...	...	...	...	...	...	...	...	...	...	3	1	...	...	2	1	1	...	1	...	5	...	4	...	5	1	3	...	...
A-3....	45	7	3	...	3	3	...	1	4	...	1	...	...	...	...	...	...	...	...	...	2	...	...	...	3	5	1	...	...	...	...	...	9	...	1	3	5	1	1
A-4....	11	6	1	3	...	4	...	...	2	...	...	...	...	...	...	...	1	...	...	...	...	1	...	...	1	...	...	...	1	...	1	...	4	...	...	3	1	...	...
A-5....	42	15	4	3	4	...	1	2	8	2	...	...	...	1	...	1	1	2	...	...	10	1	1	...	2	1	2	...	1	2	4	...	6	1	2	5	4	1	1
A-6....	11	3	...	...	...	1	...	1	1	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	3	...	...	3	...	...
B-1....	10	3	...	1	...	2	1	...	4	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	1	...	...	1	...	...	...	1	1	...	1	3	...	...
B-2....	41	11	4	4	2	8	1	4	...	...	...	...	...	1	...	...	...	1	...	...	3	1	...	...	2	2	...	1	1	1	1	...	6	1	2	4	6	1	1
C-1....	52	6	2	...	...	2	...	...	...	...	3	1	4	...	2	3	1	12	...	5	2	...	1	3	1	...	3	2	...	1	3	2	2	...	...	2	5	2	...
C-2....	12	4	...	1	...	...	...	...	...	3	...	...	2	...	1	...	...	2	...	...	...	...	...	1	...	...	...	...	...	...	...	...	2	...	...	...	3	1	...
C-3....	14	...	...	...	...	...	...	...	...	1	...	...	2	1	2	2	2	1	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...
C-4....	20	1	...	...	...	...	...	...	...	4	2	2	...	...	3	...	2	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	...	...	4	1	...
C-5....	11	1	...	...	...	1	1	1	1	...	...	1	...	...	...	1	1	1	2	6	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	3	...	...
C-6....	16	...	...	...	...	...	...	...	...	2	1	2	3	...	...	...	1	2	1	1	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	2	1	...
C-7....	15	1	...	...	...	1	...	...	...	3	...	2	...	1	...	...	...	2	...	3	3	...	...	...	1	...	1	2	...	...	1	...	1	...	...	...	2	1	...
C-8....	28	...	...	...	1	1	...	...	...	1	...	2	2	1	1	...	...	...	1	1	...	...	...	2	...	...	1	1	...	...	...	...	...	...	...	...	1	...	...
C-9....	22	1	...	...	...	2	1	1	1	12	2	1	...	1	2	2	...	...	...	3	1	...	...	5	...	...	1	2	...	...	...	1	...	1	...	1	4	1	...
C-10...	16	...	...	...	...	...	...	...	...	...	...	1	...	2	1	...	1	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
C-11...	29	...	...	...	...	...	...	...	...	5	...	2	...	6	1	3	1	3	2	...	...	...	...	1	1	...	...	2	...	...	...	2	1	...	...	...	3	...	...
D-1....	88	9	3	2	...	10	...	...	3	2	...	...	...	...	...	3	...	1	...	...	...	5	1	1	2	...	3	5	...	2	3	...	2	...	1	2	5	1	...
D-2....	21	2	1	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	5	...	...	1	2	1	...	1	2	...	1	...	1	...	...	...	1	...	...
D-3....	4	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	3	1	...	...	...	...	...	...	...	...	...	...	2	1	...
D-4....	40	1	...	...	...	...	...	...	...	3	1	...	...	...	1	...	2	5	...	1	1	1	...	...	...	...	2	8	...	...	...	1	...	...	...	...	3	1	...
D-5....	28	3	2	3	1	2	...	...	2	1	...	...	...	...	...	1	...	...	...	1	2	2	3	...	...	5	...	1	1	...	2	...	4	...	...	...	5	2	...
D-6....	16	2	1	5	...	1	...	1	2	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	5	...	...	...	...	...	...	...	3	...	...	...	3	1	...
D-7....	35	2	1	1	...	2	...	...	...	3	...	...	...	...	...	1	1	1	...	...	3	...	...	2	...	...	...	2	...	2	1	...	2	...	...	1	1	...	1
D-8....	26	1	...	...	...	...	...	...	1	2	...	...	1	...	...	2	1	2	...	2	5	1	...	8	1	...	2	...	...	...	1	...	...	...	...	...	2	...	...
D-9....	16	1	1	...	1	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	1	...	...	...	...	...	3	...	1	1	...	...	1	...	...
D-10...	28	2	...	...	...	2	...	...	1	1	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	2	...	...	...	2	...	...	...	1	1	1	...	...
D-11...	34	7	5	...	1	4	1	...	1	3	...	...	...	...	...	1	...	...	...	...	3	1	...	...	2	...	1	1	3	2	...	3	2	1	...	2	3	...	...
D-13...	33	...	...	...	...	...	...	...	...	2	...	...	...	...	1	...	...	1	...	2	...	...	...	1	...	...	...	...	...	...	3	...	1	...	...	...	1	...	...
E-1....	31	16	4	9	4	6	...	1	6	2	2	...	1	1	...	1	...	...	...	1	2	1	...	...	4	3	2	...	1	...	2	1	...	...	1	4	7	3	...
E-2....	3	1	...	...	...	1	3	1	1	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...	3	...	...
E-3....	10	5	5	1	...	2	...	...	2	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	1	...	...	1	1	...	...
E-4....	15	4	1	3	3	5	...	1	4	2	...	...	...	...	...	...	...	1	...	...	2	...	...	...	...	...	1	...	...	1	2	...	4	...	1	...	2	...	1
E-5....	35	9	3	5	1	4	3	3	6	5	3	2	4	3	2	2	1	4	1	3	5	1	2	3	5	3	1	2	1	1	3	1	7	3	1	2	...	5	1
E-6....	9	3	...	1	...	1	...	...	1	2	1	1	1	...	1	1	...	1	...	...	1	...	1	1	2	1	...	...	...	...	...	...	3	...	...	...	5	...	...
E-7....	7	...	...	1	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	1	...	...

addition, in the case of standards, of a second number indicating the year in which the standard was adopted.[1]

At the March meeting of Committee E-5 the titles of all committees were considered in detail and slight changes were made in the titles of Committees A-3, A-6 and C-10, subject to the approval of the committees themselves. Committee A-3 has accepted this proposed change and will hereafter be known as Committee A-3 on Cast Iron instead of Committee A-3 on Cast Iron and Finished Castings. Committee A-6 has not yet acted on the suggested change and Committee C-10 has taken negative action on the proposed change in its title.

This report is issued over the signature of the vice-chairman, due to the illness of the chairman of the committee, Mr. Edgar Marburg, whose physicians have ordered a complete rest for several months.

This report has been submitted to letter ballot of the committee, which consists of 35 members, of whom 31 have voted affirmatively, none negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. E. SKINNER,
Vice-Chairman.

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[1] Messrs. Charles W. Burrows, S. S. Voorhees and Richard L. Humphrey, the Sub-Committee on Classification of Standing Committees and Standards, dissent from the views of the committee for the reasons given in Appendix II to this report.

APPENDIX I.

CHANGES IN THE REGULATIONS GOVERNING STANDING COMMITTEES.

The following changes in the Regulations Governing Standing Committees have been made by Committee E-5 and have been approved by the Executive Committee:

1. Change the "Note" following the title to read as follows by the addition of the words in italics:

> "NOTE.—By action of the Executive Committee on January 6, 1912, the responsibility for the general Regulations Governing Standing Committees is vested in *the Executive and* Committee E-5 on Standing Committees, with the understanding (1) that a proposed change in these Regulations originating with Committee E-5 shall be subject to approval by the Executive Committee of the Society; (2) that the Executive Committee of the Society shall make no changes in these Regulations without first referring the same to Committee E-5; *and (3) that proposed changes in these Regulations thus adopted shall be announced in the next circular to members and become effective from the date of issue of that circular.*"

2. Change paragraph 3 of the section on "Appointments," namely:

> "As a general policy, only one representative from a given firm, company, corporation, laboratory, or other institution shall be eligible to independent membership on a given committee, although exceptions to this rule may be permitted at the discretion of the committee concerned. If the membership on the committee is held in the name of a firm, company, corporation, laboratory, or other institution, more than one representative may, at the discretion of the committee concerned, participate in its activities, with the understanding that such representatives shall jointly command only a single vote.",

to read:

> "As a general policy, only one individual connected with a given firm, company, corporation, laboratory, or other institution, shall be eligible to membership on a given committee, although exceptions to this rule may be permitted at the discretion of the committee concerned. In case two or more members of a committee are connected with the same firm, company, corporation, laboratory or other institution, they shall, when a division is demanded, jointly command only a single vote."

3. Change the section on "Permanent Organization" to read as follows by the addition of the words in italics:

> "At the first meeting of a committee a permanent organization shall be effected by the election of a permanent chairman from among the representatives of non-producing interests, and such other officers and sub-committees as the committee may desire. The duties and powers assigned to these officers and sub-committees, and the details of management and administration in general, shall be at the discretion of each committee, subject to the limitations of these regulations.
>
> "*The meetings of committees and sub-committees shall be open only to their own members and to such visitors whose proposed invitation has been approved by the chairman.*"

4. Change the section on "Proxies" to read as follows by the addition of the words in italics:

> "A member of a standing committee shall be authorized to delegate any desired individual as his proxy with voting power, *or without voting power, if so specified;* but no individual shall have more than one vote at a meeting of a committee."

5. Change the section on "Sub-Committees" to read as follows by the addition of the words in italics:

> "*Sub-committees shall have no standing in the Society except through their parent committees.* Sub-committees on proposed complete standard specifications for materials

> shall consist of not fewer than six members, and at least one-half of the membership shall be composed of non-producers. Departures from this requirement for exceptional reasons may be authorized by the Executive Committee."

6. Change the first two sentences of the section on "Reports," namely:

> "The reports of standing committees shall be presented at the annual meetings. Such reports must have been submitted to letter ballot of the committee and must have received the approval of the majority of those voting.",

to read:

> "The reports of standing committees shall be presented at the annual meetings. The report of every subcommittee shall be made to the parent committee and not to the Society direct. If such a report is embodied wholly or in part in the report of the parent committee to the Society, the latter shall make definite references to such features in its own report, and recommendations, if any, based thereon.
>
> "The report of a standing committee, before its presentation at the annual meeting, must first have been submitted to letter ballot of the committee and must have received the approval of the majority of those voting."

APPENDIX II.

STATEMENT OF SUB-COMMITTEE ON CLASSIFICATION OF STANDING COMMITTEES AND STANDARDS.

The undersigned recognize that our views, as a sub-committee appointed to consider and report on the classification of Standing Committees and Standards (which were considered at length by the Committee at several of its meetings) are not in accord with those of a majority of the members of the Committee on Standing Committees. While it may not be opportune to adopt our recommendations at this time, we believe that our proposal, which represents a great deal of study and labor on our part and which possesses at least some meritorious features, should be published in the Proceedings of the Society, where it will be available to all its members. For this purpose we submit a condensed report, embodying our essential recommendations.

Objects in View.

We have given careful consideration to the functions of the various branches of the Society and believe that the time has arrived when it is desirable for the Society to consider a more logical form of organization in which the duties of each branch are specifically defined. In order that the proposed plan of organization may be understood, we have indicated diagrammatically in Fig. 1, for convenience of reference, the relation of the various committees of the Society to the Executive Committee, outlined their functions as at present constituted, indicated how such committees as the four covered in the Administrative Group should in our opinion be constituted, and have defined their functions. In the case of the Committee on Papers and Publications and the Committee on Technical

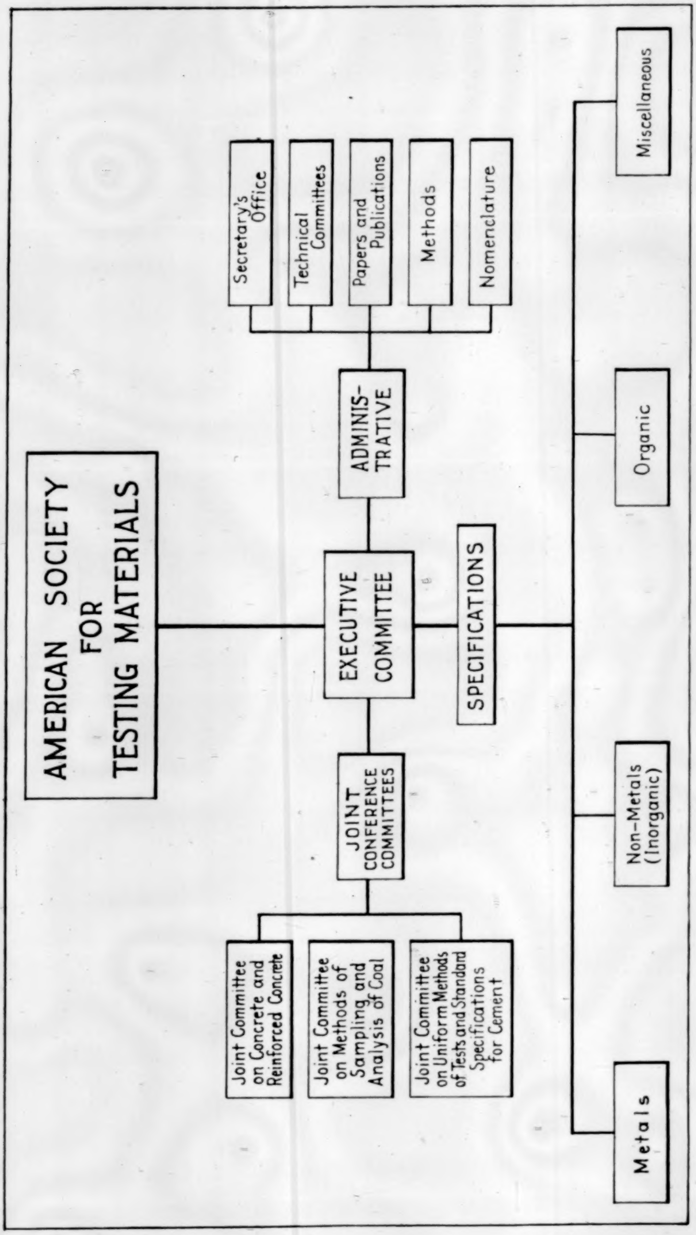
AMERICAN SOCIETY FOR TESTING MATERIALS
EXECUTIVE COMMITTEE
JOINT CONFERENCE COMMITTEES
Joint Committee on Concrete and Reinforced Concrete
Joint Committee on Methods of Sampling and Analysis of Coal
Joint Committee on Uniform Methods of Tests and Standard Specifications for Cement
ADMINIS-TRATIVE
Secretary's Office
Technical Committees
Papers and Publications
Methods
Nomenclature
SPECIFICATIONS
Metals
Non-Metals (Inorganic)
Organic
Miscellaneous

FIG. 1.

Committees, there are no changes in their constitution, nor is the Committee on Methods changed, but its organization has been more clearly defined. In order that there may be no misunderstanding we here state that we have two objects in view, namely:

1. A concise descriptive name only for each committee; and
2. A logical system of classification of all committees.

CRITICISM OF THE PRESENT SYSTEM.

As a Sub-Committee of the Committee on Standing Committees we were requested to indicate wherein the present system was defective, and the following was prepared in compliance with this request:

1. It is not found necessary nor is it the usual practice among the national societies of this country, to designate committees by letters and numbers; but it is the practice to give them descriptive names indicative of their character. The above statement applies to all the principal national engineering societies.

2. It is also not the practice in foreign engineering societies to designate committees by letters or numbers, but to use a descriptive title indicative of their character.

3. The British Engineering Standards Committee, whose work is along similar lines and is as important and far-reaching as that of the American Society for Testing Materials, does not find it necessary to use letters or numbers, but designates its committees by concise descriptive titles as recommended by your sub-committee.

4. The Association of American Steel Manufacturers does not use letters or numbers to designate its specifications and it would seem, in view of the large number of its members who are also members of the Committee on Steel, that it would avail itself of the system of designation at present in use in the American Society for Testing Materials if it felt that it served a useful purpose, especially since its standards are similar to those of the Committee on Steel of the A.S.T.M.

5. Your sub-committee has had a number of examples of where members interested in the work of the Society have been confused by the alphabetical and numerical designation

and expressed a desire for a name more indicative of the work of the committee. While it was the sense of the last meeting of the Committee on Standing Committees that the present method of designating committees should be retained, your sub-committee has not received any valid reasons for its continuance and it still maintains its objections to the system.

6. There is no logical basis for the arbitrary letters and numbers at present used to designate committees. The confusion that results from the frequent changes in the arbitrary designation of committees would not occur if the committees were designated by descriptive titles.

The records of the Society reveal numerous examples of such changes. For example: The former Committee E-1 on Preservative Coatings is now D-1; the former Committee D-3 on Gypsum and Gypsum Products is now C-11; the former Committee A-10 on Hardness is now a sub-committee of E-1 on Methods of Testing; the identities of former Committees A-7, A-8, A-9 and A-12 are lost as sub-committees of A-1; the designation D-3 was applied to the Committee on Standard Methods of Analyses of Fats and Oils (1910), then it went into disuse (1913), then it was applied to the Committee on Gypsum and Gypsum Products (1914), then again went into disuse (1915), and at present is applied to the Committee on Sampling and Analysis of Coal (1916). From the many other examples the following is cited: The Committee on Staybolt Iron was formerly designated by the letter "M" (1907), later it was designated as A-10 (1910), and is now a sub-committee of A-2; if steel should be used for staybolts how would the committee be designated? If it had been designated as the Staybolt Committee, as recommended by your sub-committee, such confusion could not have occurred.

These examples support the contention that the present system of letters and numbers to designate committees does not designate them.

Such letters and numbers must be supplemented by descriptive titles; then why not use only a concise descriptive title as recommended.

We present graphically in Fig. 2 the present system of classification in which the committees are indicated by letters

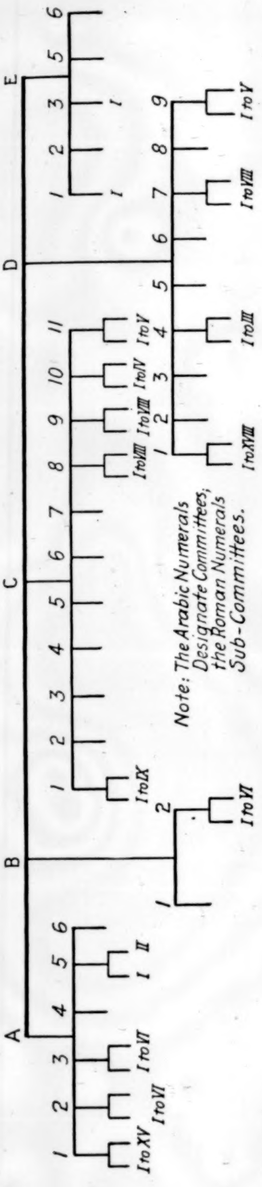
A
1
I to XV
2
I to VI
3
I to VI
4
5
I
II
6
B
1
2
I to VI
C
1
I to IX
2
3
4
5
6
7
8
I to VIII
9
I to VIII
10
I to V
11
I to V
D
1
I to XVIII
2
3
4
I to III
5
6
7
I to VIII
8
9
I to V
E
1
I
2
3
I
5
6
Note: The Arabic Numerals Designate Committees; the Roman Numerals Sub-Committees.

FIG. 2.

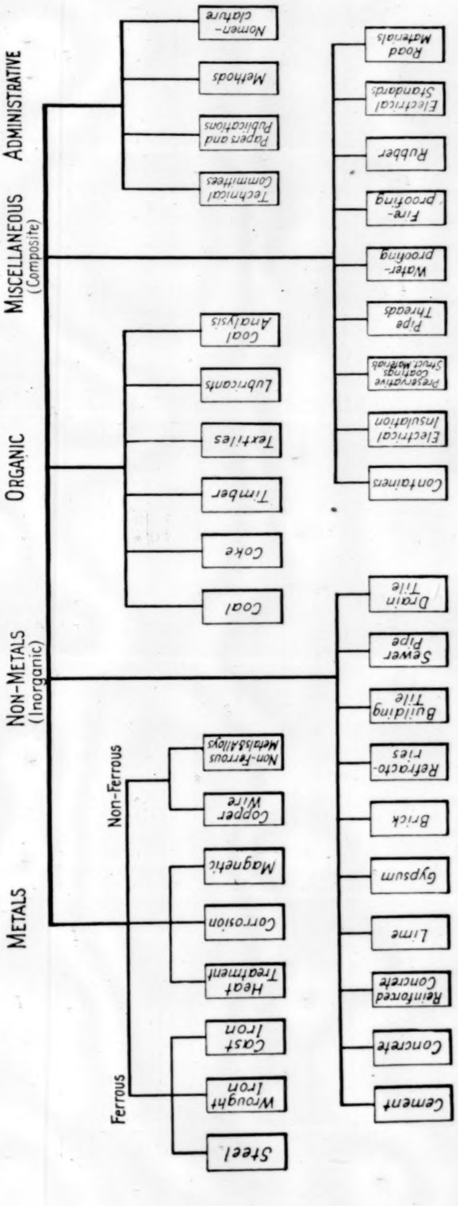
METALS
Ferrous
Steel
Wrought Iron
Cast Iron
Heat Treatment
Corrosion
Magnetic
Non-Ferrous
Copper Wire
Non-Ferrous Metals & Alloys
NON-METALS (Inorganic)
Cement
Concrete
Reinforced Concrete
Lime
Gypsum
Brick
Refracto-ries
Building Tile
Sewer Pipe
Drain Tile
ORGANIC
Coal
Coke
Timber
Textiles
Lubricants
Coal Analysis
MISCELLANEOUS (Composite)
Containers
Electrical Insulation
Preservative Coatings Struct. Materials
Pipe Threads
Water-proofing
Fire-proofing
Rubber
Electrical Standards
Road Materials
ADMINISTRATIVE
Technical Committees
Papers and Publications
Methods
Nomen-clature

FIG. 3.

and numbers, from which it is apparent that the diagram is meaningless without a descriptive title.

7. There is no relation between identical letters and numerals now used to designate committees and standards. For example: A-5 designates the Committee on Corrosion of Iron and Steel, and the Standard for High-Carbon Steel Splice Bars; B-2 designates the Committee on Non-Ferrous Metals and Alloys, and the Standard for Medium Hard-Drawn Copper Wire; C-7 designates the Committee on Lime and the Standard for Paving Brick; D-2 designates the Committee on Lubricants, and Standard Tests for Abrasion of Road Material.

8. Again, there is no relation between the letters and numbers that designate a committee and the standards promulgated by it. For example: A committee formerly designated as A-10 on Standard Specifications for Staybolt Iron, now Sub-Committee III of Committee A-2, has promulgated standard A-39 for Staybolt Iron; Committee B-1 on Copper Wire has promulgated standard B-2 for Medium Hard-Drawn Copper Wire, while B-2 on Non-Ferrous Metals and Alloys has promulgated standard B-6 for Spelter; Committee C-1 on Cement has promulgated standard C-1 for Cement, recently replaced by Standard C-9 for Specifications and Tests for Portland Cement and C-10 for Specifications for Natural Cement; Committee D-6 on Coke has promulgated standard D-17 for Foundry Coke. The present practice of using similar but not identical letters and numbers to designate committees and standards certainly results in much confusion.

RECOMMENDED SYSTEM OF CLASSIFICATION.

Figs. 2 and 3 deal exclusively with the classification of the present committees. In the one the committees are designated as at present by letters and numbers, and in the other by a brief descriptive title. In order that the proposed plan of organization may be understood your sub-committee submits the following duties for the various committees:

Executive Committee.

The Executive Committee shall administer the affairs of the Society in the interim between its meetings as outlined in the by-laws of the Society. Its functions should be largely judicial and it is expected that the detailed work shall be performed by the administrative group, whose recommendations shall be acted upon by the Executive Committee. The Executive Committee shall promulgate rules for the organization and procedure of conference committees and shall supervise their activities.

Conference Committees.

We believe that conference committees, composed of special committees of this Society and of other organizations in similar lines of activity, should be approved, recognized and encouraged by the Society for the reason that it tends to develop uniformity in standards and to promote cooperation between organizations.

Administrative Group.

(*a*) *Secretary's Office.*—The Secretary-Treasurer shall be charged with such duties as the Executive Committee may determine.

(*b*) *Technical Committees.*—The Committee on Technical Committees shall be composed of the chairmen of existing committees of the Society or their authorized representatives and its duties shall be:

1. To create, classify and outline the scope of the work of all committees;
2. To promulgate Regulations Governing Technical Committees;
3. To promulgate rules governing the form but not the substance of standards; and
4. To arbitrate disputes which may arise in committees or between the different committees of the Society.

All matters coming under the jurisdiction of this committee should be primarily discussed by it and after its action the matter should be passed upon by the Executive Committee. Suggestions therefor, originating in the Executive Committee, should be first submitted to this committee for consideration.

(*c*) *Papers and Publications.*—The duties shall be the same as at present.

The chairman of the Committee on Technical Committees and of the Committee on Papers and Publications shall be the Secretary of the Society.

(*d*) *Methods.*—This committee shall be constituted from the chairmen of the committees or their authorized representatives, and its work is essentially the unification of the methods developed by the various committees.

(*e*) *Nomenclature.*—This committee shall be constituted from the chairmen of the committees, or their authorized representatives, and its work shall be the unification of the differences which originate in the various committees and it also shall be charged with the duty of preparing a glossary of terms used in the specifications and methods promulgated by the Society. We believe that this volume will be of great value and command a ready sale.

Specification Group.

We have attempted the classification of the activities of the Society in a logical way and realize that this classification is not perfect. We believe that this subject should be under the jurisdiction of and be developed by the Committee on Technical Committees and that it should be subject to change and modification to meet conditions as they arise.

We believe that the present designation of committees by letters and numbers is objectionable.

It is our intention that the classification proposed shall not be used for other than administrative purposes in the classification of committees. We believe that each committee should be designated by a short, descriptive title indicative of its work. Your sub-committee has divided the activities into four groups:

1. Metals;
2. Non-Metals (inorganic);
3. Organic;
4. Miscellaneous (composite); specifications involving the use of two or more materials of the other groups.

In each group there is a tri-unity of functions that relate to:

1. Materials;
2. Methods;
3. Nomenclature.

The elimination of letters and numbers in the designation of committees is highly desirable, for the reason that the title does not affect the classification of any committee, and therefore, its position can be changed without disturbing its title. All of the plan of organization above the specification group are fundamental matters of organization which should be settled without a great difference of opinion.

We call your attention to the fact that the plan proposed does not change the present title of the Committees on Specifications. It does away, however, with arbitrary, alphabetical and numerical titles, provides a usable title, and presents a logical and flexible basis of classification to be developed by the Committee on Technical Committees.

We have not attempted to define the functions of the Committees on Specifications. While such a definition of activities is desirable, we feel, however, that the chairmen should first be asked to define the scope of the work of their respective committees and these recommendations should then be submitted to the Committee on Technical Committees, who should finally define the scope of the work of the various committees, and should make such subsequent modifications as may be found necessary or desirable.

We realize that we have by no means completely solved this important problem of thoroughly organizing the work of the Society along rational lines. Our purpose has been to show the inadequacy of the present methods and to point out the manner in which they may be improved. We believe that this subject merits the further careful consideration of the Committee on Standing Committees and we trust that there may be evolved a reorganization of the activities of the Society, which will be a logical and satisfactory solution of the problem.

In the plan proposed it is expected that the Executive Committee will be relieved of much of the detail work that it is now called upon to perform, and further that this detail work should be handled by various committees of the Administrative Group, of which the Committee on Technical Committees, constituted of the chairman or representative of each of the standing committees, is considered by your sub-committee, next to the Executive Committee, the most important committee in the Society.

CONCLUSION.

We feel that our recommendations would eliminate the confusion and undesirability of the present system; and that the supposed merit of the present system, which is not found desirable in other organizations dealing with standards, is psychological, and that the members of the Society would find the system recommended just as meritorious if it was in general use. The system recommended at least has this important merit: that there never could be any ambiguity as to the nature of the work of the committee so designated and it places it in the group where it logically belongs.

As new subjects are brought to the attention of the Society they will not only automatically fall into one of the existing groups, but may logically be assigned to one of the existing committees for consideration and report, and so prevent the formation of unnecessary new committees.

We appreciate the imperfections of the system submitted and believe that with the cooperative support of all the members of the Committee on Standing Committees, it could be developed to a reasonable perfection.

The system proposed, while not perfect, is logical and flexible and can be developed as experience would indicate.

We recommend:

1. The adoption of concise, descriptive titles only for all committees, with the elimination of letters and numbers; and
2. A logical and flexible system of classification of committees on lines of that proposed.

Respectfully submitted,

CHARLES W. BURROWS,
S. S. VOORHEES,
RICHARD L. HUMPHREY,
Chairman.

REPORT OF COMMITTEE E-6

ON

PAPERS AND PUBLICATIONS.

Since the last annual meeting there has been no occasion to hold a general meeting of Committee E-6. Its functions relative to the acceptance of papers have been discharged by the Advisory Committee and other members of the committee who have given individual expert advice. The committee has also received assistance of this kind from members of the Society not connected with the committee, for which it desires to record its appreciative acknowledgment.

The program this year is one of the largest in the history of the Society. It contains 30 committee reports and 30 papers, as compared with 27 committee reports and 22 papers last year. The Advisory Committee has had to decline numerous offers of papers received after the expiration of the limiting date announced in a circular to members. It has also been found necessary to decline, for various reasons, certain offers received at an earlier date, as well as several papers which had been provisionally accepted by title. The material in view for this meeting aggregates 1074 pages, as compared with 937 pages for last year.

In its report last year, the committee mentioned certain matters relating to the methods governing the presentation of committee reports which might be improved. These will be taken up in order as follows:

1. *Distribution of Committee Reports Affecting Standards.*—The present Regulations Governing Standing Committees provide that:

> "Any recommendations affecting standards must be transmitted to the Secretary-Treasurer of the Society at least eight weeks in advance of the date of the annual meeting, and copies of these recommendations, in printed form, must be mailed by the Secretary-Treasurer to every member of the Society not less than four weeks before the annual meeting, so that

members may come to the meeting prepared to discuss such recommendations, and that members not intending to be present at the meeting may contribute discussions by letter."

The committee regrets to announce that although every effort has been made to secure the manuscripts of reports affecting standards earlier than the prescribed eight weeks, the conditions in this respect have not been improved over the showing made last year. According to the regulations above quoted, the manuscripts of the 18 committee reports submitted this year affecting standards should have been sent to the Secretary-Treasurer not later than May 1, and they should all have been included in the first instalment of preprints mailed to the membership at large on May 29. However, as may be seen from Table I, nine reports were not received till after May 1, of which five, whose average date of receipt was May 5, were included in the first instalment. The average date of receipt of the remaining four was May 17. These reports had accordingly to be included with the second instalment of preprints issued on June 14.

It must be left to the Society in annual meeting assembled to determine whether the violation of the regulations to the extent of rendering it impossible to comply with the requirements governing the limiting date for the distribution of the reports, is to be taken into account in the consideration of the proposed tentative standards embodied in those reports.

2. *Sub-Committee Reports.*—Last year the committee pointed out the "tendency on the part of certain committees to transmit for publication in connection with the report of the main committees, reports of sub-committees which had not previously been presented for discussion to the parent committee and on which in some instances little or no comment is made in the report of the main committee." The following sentences were, therefore, added to the Regulations Governing Standing Committees by joint action of the Executive Committee and Committee E-5 on Standing Committees, as announced in Circular No. 113 to members, November, 1916:

> "Sub-committees shall have no standing in the Society except through their parent committees . . . . . .

"The report of every sub-committee shall be made to the parent committee and not to the Society direct. If such a report is embodied wholly or in part in the report of the parent committee to the Society, the latter shall make definite reference to such features in its own report and recommendations, if any, based thereon."

The committee is glad to state that committee reports submitted this year have been most satisfactory in this respect.

TABLE I.—ANALYSIS OF PREPRINTING.

Instalment No.	Date of Mailing.	Committee Reports.										Papers.		Total.	
		Affecting Standards; Due May 1.				Not Affecting Standards.				Total.					
		Received before May 1, on Average Date Shown.		Received after May 1, on Average Date Shown.		Received before May 1, on Average Date Shown.		Received after May 1, on Average Date Shown.							
		No.	Pages.	No.	Pages.	No.	Pages.	No.	Pages.	No.	Pages.	No.	Pages.	No.	Pages.
1	May 29.....	9 (April 23)	189	5 (May 5)	66	2 (April 15)	64	..	..	16	319	13 (April 15)	155	29	474
2	June 14.....	..	..	4 (May 17)	43	..	..	5[a] (May 19)	85	9[a]	128	9 (May 7)	153	18[a]	281
3	June 20.....	..	..	..	..	..	..	3 (May 26)	80	3	80	6 (May 17)	143	9	223
4	Not mailed; printed for Annual Meeting only.......	..	..	..	..	..	..	3 (June 13)	49	3	49	3[b] (June 8)	47	6[b]	96
						Totals...............				31[a]	576	31[b]	498	62[a, b]	1074

[a] Includes two preprints which are part of and complete two committee reports in the first instalment.
[b] Includes one preprint which is an appendix to a paper in the third instalment.
NOTE.—In addition to the above, a Discussion on the Report of Committee B-2 has been printed for use at the Annual Meeting.

3. *Editing of Committee Reports.*—The committee suggested last year the deferring of the letter ballot upon committee reports requiring considerable modification for publication, until after such modification had been approved by the chairmen of the committees concerned. The committee is not in a position to state to what extent this recommendation has been observed. However, in no case was it found necessary to make drastic modifications of committee reports this year.

4. *Letter Ballot on Committee Reports.*—Last year the committee emphasized the desirability of taking effective measures to obtain a full vote by letter ballot on all committee reports. Although a number of committee reports have been received so late that the results of the letter ballot thereon will have to be announced when the report is presented at the annual meeting, the committee is confident that every effort has been made by the chairmen of the various committees concerned to secure a full vote on their respective reports.

The accompanying diagram (Fig. 1) affords a more comprehensive and detailed view of the general situation relative to preprints with reference to (1) the date of receipt of manuscripts; (2) the number of printed pages in each item; and (3) the contents as to pages and the mailing date of each instalment of preprints.

Notwithstanding the lateness of the receipt of many of the manuscripts, it has been found possible to have every item on the program available at the annual meeting in printed form, with the exception of one committee report. It should be pointed out, however, that to accomplish this, it has been necessary not only to adopt a night schedule for printing for the last six weeks at a considerable expense for overtime charges, but also to send approximately one-third of the committee reports and papers to press without giving the chairmen of the committees or the authors an opportunity to examine the proof and to indicate any corrections they might have wished to make. (This has not proved to be a serious matter, since in only a few cases have any changes been made by committee chairmen or authors after such reports or papers had been printed, and these will be announced at the annual meetting.) Furthermore, there has not been sufficient time for properly editing the considerable number of proposed new tentative standards contained in the various committee reports. These will have to be more carefully edited as to form after the annual meeting, subject to the approval of the chairmen of the committees concerned.

In view of the above considerations, and the constant increase in the volume of our publications, Committee E-6

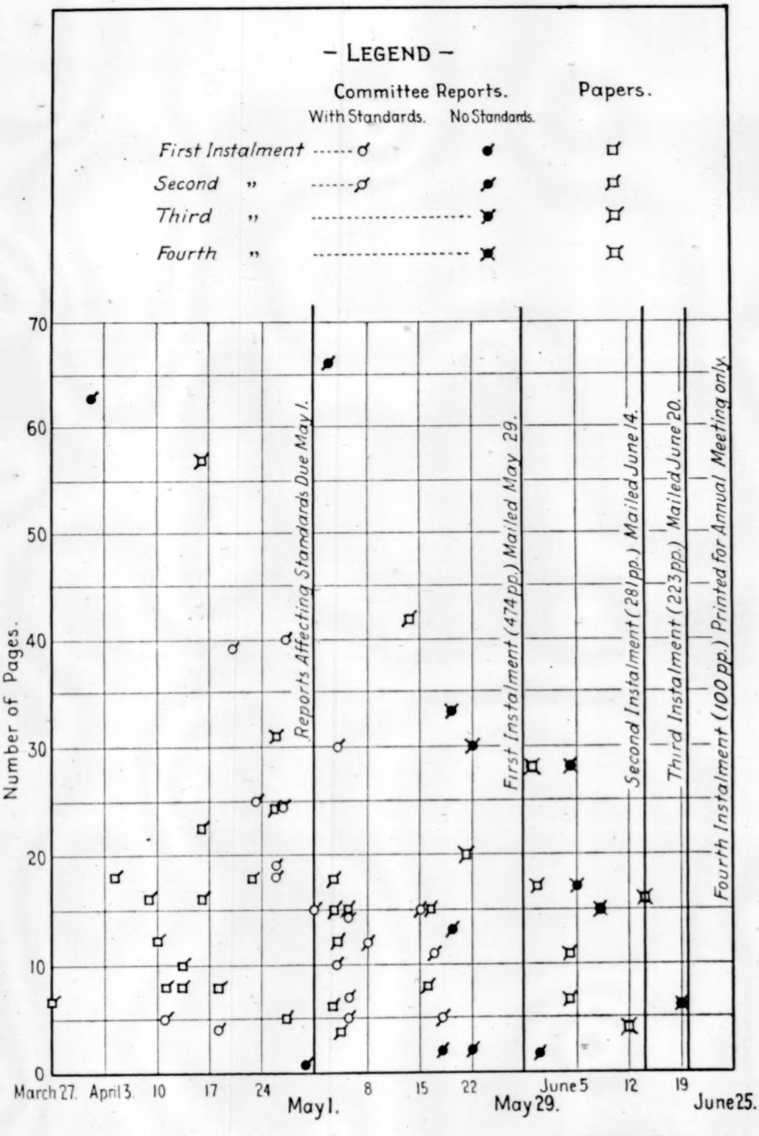

FIG. 1.—Statistics of Preprints. Position of Symbol Indicates Content as to Number of Pages and Date of Receipt of Manuscripts of Every Paper and Committee Report.

believes that some steps should be taken looking towards the earlier submission to the committee of both committee reports and papers, and especially reports containing recommendations as to standards or tentative standards. It is hoped that this question will receive the early consideration of the Executive Committee.

The comparative data for preprints since 1913, when preprinting was first undertaken on an extensive scale, are given in Table II.

From this it will be seen that the volume of preprinted matter for this year exceeds that for any previous year, both as to number of pages distributed in advance and the total amount available at the annual meeting. It may also be interesting to note that the amount distributed in advance exceeds the total of any previous year.

TABLE II.—COMPARATIVE DATA FOR PREPRINTS.

Year.	Preprints.			On Program, but not Preprinted, pages.
	Distributed in Advance, pages.	Not Distributed in Advance, pages.	Total, pages.	
1913	461	238	699	81
1914	668	260	928	11
1915	891	76	967	0
1916	846	91	937	0
1917	978	96	1074	about 4

This report has been submitted to letter ballot of the committee, which consists of nine members, all have voted affirmatively.

Respectfully submitted on behalf of the committee,

EDGAR MARBURG,
Chairman.

A.S.T.M.
TENTATIVE STANDARDS

CONSISTING OF

TENTATIVE SPECIFICATIONS, TENTATIVE TESTS,
TENTATIVE METHODS, TENTATIVE
DEFINITIONS AND TENTATIVE
RECOMMENDED PRACTICE.

The term Tentative Standards is applied to proposed Standards which are printed for one or two years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards the adoption of such Tentative Standards by formal action of the Society.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee whose name and address appear in the footnote to the title of each Tentative Standard.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
STEEL TRACK SPIKES.[1]

Serial Designation: A 65 – 16 T.

The specifications for this material are issued under the fixed designation A 65; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

I. MANUFACTURE.

Process. 1. The steel may be made by the Bessemer or open-hearth process.

II. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 2. The full-size finished spikes, or the full-size bars from which the spikes are made, shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	55 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 2 in., per cent	25

Bend Tests. 3. (*a*) The body of the full-size finished spikes shall bend cold through 180 deg. flat on itself, without cracking on the outside of the bent portion.

(*b*) The head of the full-size finished spikes shall bend backward to the line of the face of the spike without cracking on the outside of the bent portion.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, University of Pennsylvania, Philadelphia, Pa.

Number of Tests. 4. (*a*) One tension and one bend test of each kind shall be made from each lot of 10 tons or fraction thereof.

(*b*) If any test specimen develops flaws, it may be discarded and another specimen substituted.

Retests. 5. If any tension test specimen breaks more than $\frac{3}{4}$ in. from the center of the gage lenght, a retest shall be allowed.

III. WORKMANSHIP AND FINISH.

Workmanship. 6. The spikes shall conform to the dimensions specified by the purchaser. A variation of $\frac{1}{64}$ in. under the specified dimension of the body of the spike, measured from the face to the back, and a variation of $\frac{1}{32}$ in. over the specified dimension of the body of the spike, measured across the face, will be permitted. A variation of $\frac{3}{32}$ in. over and $\frac{1}{32}$ in. under the specified dimensions of the head of the spike will be permitted. A variation of $\frac{1}{8}$ in. from the specified length of the spike, measured from the under side of the head to the point, will be permitted. A variation of 1 deg. in the specified angle of the under side of the head of the spike will be permitted.

Finish. 7. The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

V. INSPECTION AND REJECTION.

Inspection. 8. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 9. Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

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TENTATIVE SPECIFICATIONS
FOR
STEEL SCREW SPIKES.[1]

Serial Designation: A 66 - 16 T.

The specifications for this material are issued under the fixed designation A 66; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

I. MANUFACTURE.

Process. 1. The steel may be made by the Bessemer or open-hearth process.

Finishing. 2. The heads of the spikes shall be formed and the threads rolled at a temperature not less than 750° C.

II. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 3. The full-size finished spikes shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	60 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 2 in., per cent	20

Bend Tests. 4. The full-size finished spikes shall bend cold through 90 deg. around a pin the diameter of which is equal to three times the diameter of the spike, without cracking on the outside of the bent portion.

Number of Tests. 5. (*a*) One tension and one bend test shall be made from each lot of 100 kegs or fraction thereof.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, University of Pennsylvania, Philadelphia, Pa.

(*b*) If any spike tested develops flaws, it may be discarded and another spike substituted.

Retests. 6. (*a*) If the percentage of elongation of any tension test spike is less than that specified in Section 3, a retest shall be allowed.

(*b*) If any tension test spike breaks more than $\frac{3}{4}$ in. from the center of the gage length, a retest shall be allowed.

III. WORKMANSHIP AND FINISH.

Workmanship. 7. The spikes shall conform to the dimensions specified by the purchaser. The head shall be concentric with, and firmly joined to, the body of the spike. The threads shall be sharp and true to gage and of the pattern specified by the purchaser. A variation of $\frac{1}{32}$ in. over and under the specified diameter of the unthreaded portion of the body of the spike will be permitted. A variation of $\frac{1}{32}$ in. over the specified diameter of the threaded portion of the spike will be permitted. A variation of $\frac{1}{16}$ in. under and $\frac{1}{8}$ in. over in the reach of the head of the spike will be permitted. A variation of $\frac{1}{8}$ in. from the specified length of the spike will be permitted.

Finish. 8. The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

IV. MARKING.

Marking. 9. A letter or brand indicating the manufacturer shall be pressed on the head of the spike while it is being formed.

V. INSPECTION AND REJECTION.

Inspection. 10. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected. and the manufacturer shall be notified.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
STEEL TIE PLATES.[1]

Serial Designation: A 67 - 17 T.

The specifications for this material are issued under the fixed designation A 67; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917.

I. MANUFACTURE.

1. The steel may be made by the Bessemer or open-hearth process. **Process.**

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition: **Chemical Composition.**

Phosphorus	Bessemer................	not over 0.10 per cent
	Open-hearth............	" " 0.05 "

3. (*a*) For steel made by the Bessemer process, the manufacturer shall furnish the inspector, daily, carbon and phosphorus determinations for each melt before the tie plates are shipped, and two chemical analyses every 24 hours representing the average of the elements carbon, manganese, phosphorus and sulfur contained in the steel, one for each day and night turn, respectively. These analyses shall be made on drillings taken from the ladle test ingot not less than $\frac{1}{8}$ in. beneath the surface. **Ladle Analyses.**

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, University of Pennsylvania, Philadelphia, Pa.

Check Analyses. 4. An analysis may be made by the purchaser from a finished tie plate representing each melt of open-hearth steel, and each melt or lot of 10 tons of Bessemer steel. The phosphorus content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 5. (*a*) Except as specified in Paragraph (*b*), the tie plates shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	64 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 2 in., per cent but in no case less than 18 per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$,
Elongation in 8 in., per cent but in no case less than 16 per cent	$\frac{1\,400\,000}{\text{Tens. str.}}$,
Reduction of area, per cent	25

(*b*) Tie plates in which the material required to be punched is $\frac{5}{8}$ in. or greater in thickness, shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	55 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 2 in., per cent but in no case less than 20 per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$,
Elongation in 8 in., per cent but in no case less than 18 per cent	$\frac{1\,400\,000}{\text{Tens. str.}}$,
Reduction of area, per cent	30

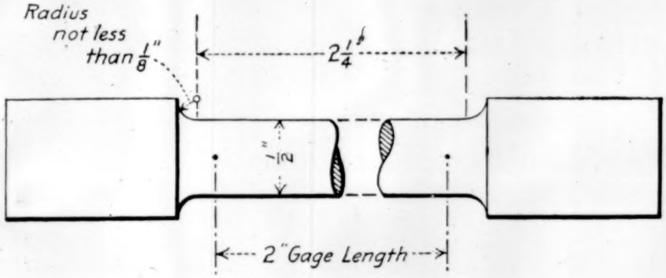
(*c*) If desired by the purchaser, or if for the reason that the design of the tie plate does not permit proper physical testing, the material may be purchased to chemical composition only; in such case the minimum carbon shall be as follows:

CORRESPONDING MINIMUM TENSILE STRENGTH.	BESSEMER.	OPEN-HEARTH.
64 000 lb. per sq. in.	0.12 per cent	0.20 per cent
55 000 " "	0.08 "	0.15 "

Test Specimens.

6. (*a*) The tension test specimens shall be taken from the finished tie plates, or from the rolled bar. They shall be cut so that the sides of the specimens are parallel to the direction in which the tie plates have been rolled.

(*b*) Tension test specimens may conform to the essential dimensions shown in Fig. 1 or Fig. 2. The 2-in. specimen (Fig. 1) shall have filleted shoulders, or threaded ends, to fit into the holders on the testing machine in such a way that the line of action of the force exerted by the testing machine shall coincide with the axis of the specimen.



Note:- The Gage Length, Parallel Portions and Fillets shall be as Shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.

FIG. 1.

(*c*) Or, tension test specimens may be rectangular in section, in which case they shall be not less than $\frac{1}{2}$ in. in width between the planed sides, and shall have two parallel faces as rolled. When the tie plates are of such a design that the rectangular specimens cannot be obtained without projecting ribs, these shall be planed off before the tests are made.

Number of Tests.

7. (*a*) One tension test shall be made from each melt of open-hearth steel, and from each melt or lot of 10 tons of Bessemer steel.

(*b*) If any test specimen shows defective machining, or develops flaws, or if it breaks outside the gage length, it may be discarded and another specimen substituted.

Retests.

8. (*a*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5, a retest shall be allowed.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. WORKMANSHIP AND FINISH.

Workmanship. 9. The tie plates shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearing for the rail. They shall be sheared to the length and punched to the dimensions specified by the purchaser, with the following permissible variations:

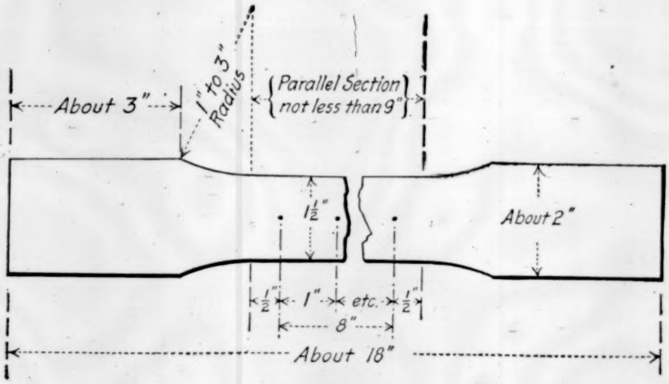


FIG. 2.

(*a*) For plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{1}{8}$ in. in rolled width, and $\frac{3}{16}$ in. in sheared length will be permitted.

(*b*) For plates with shoulders perpendicular to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{1}{8}$ in. in rolled width, and $\frac{1}{4}$ in. in sheared length will be permitted. The distance from face of shoulder to outside end of plate shall not vary more than $\frac{1}{4}$ in., and from face of shoulder to inside end no more than $\frac{1}{2}$ in.

Finish. 10. The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching; they shall also be free from other injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking. 11. The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

VI. INSPECTION AND REJECTION.

Inspection. 12. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. Unless otherwise specified, any rejection based on tests made in accordance with Section 4 shall be reported within five working days from the receipt of samples.

(*b*) Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 14. Samples tested in accordance with Section 4, which represent rejected tie plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
CARBON-STEEL BARS FOR RAILWAY SPRINGS WITH SPECIAL SILICON REQUIREMENTS.[1]

Serial Designation: A 68 – 16 T.

The specifications for this material are issued under the fixed designation A 68; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Classes. 1. (*a*) These specifications cover carbon-steel bars with special silicon requirements, to be used for the manufacture of railway springs.

(*b*) The bars are divided into two classes, determined by the carbon ranges specified in Section 3. The choice of the class of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended. The purposes for which these classes are frequently used are as follows:

Class A, for elliptical and helical springs;
Class B, for helical springs.

I. MANUFACTURE.

Process. 2. The steel may be made by the open-hearth, crucible or electric process.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, University of Pennsylvania, Philadelphia, Pa.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The steel shall conform to the following requirements as to chemical composition:

Elements Considered.	Class A.	Class B.
Carbon, per cent	0.90 - 1.10	0.95 - 1.15
Manganese, max., per cent	0.50	0.50
Phosphorus, max., per cent	0.05	0.05
Sulfur, max., per cent	0.05	0.05
Silicon, per cent	0.25 - 0.50	0.25 - 0.50

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. Analyses may be made by the purchaser from finished bars representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Permissible Variations.

6. The permissible variations in the width and thickness of the bars shall be agreed upon by the manufacturer and the purchaser.

IV. FINISH.

Finish.

7. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking.

8. The bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification.

VI. INSPECTION AND REJECTION.

Inspection. 9. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 10. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 11. Samples tested in accordance with Section 5, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS FOR ELLIPTICAL SPRINGS FOR AUTOMOBILES.[1]

Serial Designation: A 69 – 16 T.

This specifications for this material are issued under the fixed designation A 69; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Basis of Purchase.

1. (*a*) These specifications cover all elliptic springs for automobiles.

(*b*) The manufacturer and the purchaser shall agree on the type and grade of steel bars to be used.

(*c*) If carbon-steel bars, silico-manganese-steel bars or chrome-vanadium-steel bars are specified, the bars shall conform, respectively, to the Standard Specifications for Carbon-Steel Bars for Vehicle and Automobile Springs (Serial Designation: A 58), the Standard Specifications for Silico-Manganese-Steel Bars for Automobile and Railway Springs (Serial Designation: A 59), or the Standard Specifications for Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (Serial Designation: A 60), of the American Society for Testing Materials.[2]

(*d*) Drillings for chemical analysis shall be taken from pieces sheared from the bars during the process of manufacture, and not from a finished spring, unless otherwise agreed upon.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, University of Pennsylvania, Philadelphia, Pa.

[2] See 1916 Book of A.S.T.M. Standards.

I. CHEMICAL PROPERTIES AND TESTS.

Check Analyses.

2. (*a*) An analysis may be made by the purchaser from a sample representing each size of spring steel involved. The chemical composition thus determined shall conform to the requirements of Section 1 (*c*).

(*b*) Drillings for analysis shall be taken from the unworked portion of the bars and shall represent the full cross-section after rejecting any decarburized material.

(*c*) In case of dispute, check and arbitration analyses of carbon steel shall be made in accordance with the Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33) of the American Society for Testing Materials,[1] the carbon being determined by the "direct-combustion" method; and of alloy steel, in accordance with the Standard Methods for Chemical Analysis of Alloy Steels (Serial Designation: A 55), of the American Society for Testing Materials.[1]

II. WORKMANSHIP.

Inspection.

3. The purchaser or his representative may examine all springs in each lot for workmanship and general dimensions.

Workmanship.

4. (*a*) The springs shall be submitted for inspection complete in the condition required by the drawings, and shall conform to these drawings with the permissible variations specified in this section and Section 7. Dimensions which affect the contour only and do not affect the interchange or service of the spring need only be approximated.

(*b*) The springs shall have the plates properly graduated in length, properly bent, and fitted reasonably true to the curves specified.

III. PHYSICAL PROPERTIES AND TESTS.

Number of Tests.

5. All of the springs may be tested.

Methods of Testing.

6. (*a*) Full-elliptic springs shall be tested in the upright position. One-quarter-elliptic, half-elliptic, three-quarter-elliptic, and cantilever springs shall be tested in the inverted position, and shall be so supported as to give free lateral movement on compression while remaining in position selected for test. Methods of supporting and measuring the various types of springs are illustrated in Figs. 1 to 7, inclusive.

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[1] See 1916 Book of A.S.T.M. Standards.

(*b*) The anvil or pressure block of the testing machine shall be of the form shown in Fig. 8.

(*c*) Unless otherwise specified, all measurements of height are to be made as follows: in half-elliptic springs (Figs. 1 and 2), between the surfaces of the pressure block and a line joining the centers of the eyes (or through the points of support where there are no eyes); in full and three-quarter-elliptic springs (Figs. 3 and 4), between the surfaces of the upper and lower pressure blocks; in one-quarter-elliptic springs (Figs. 5 and 6), between the center of the eye (or point of support where there is no eye) and the supporting pad of the spring, measured at right angles to the surface of the latter; and in half-elliptic cantilever springs (Fig. 7), between the center of the floating eye and a horizontal plane passing through the lower surface of the spring (in inverted position) at the center bolt.

(*d*) In conducting tests, all measurements of height shall be taken to at least the nearest $\frac{1}{64}$ in. All readings of load shall be taken to at least the nearest 5 lb.

(*e*) *Maximum Test Load.*—The maximum test load required in Section 7 shall be twice the specified normal load, unless such a test load produces a deflection greater than the maximum deflection possible under the car. In the latter case, the maximum test load used shall be the load producing the maximum deflection possible under the car.

(*f*) *Application of Load.*—The application of the loads under which the height is to be measured as specified in Section 7 shall be made gradually and in such a way that the required load shall not be exceeded. If it is exceeded, the load shall be released to not more than one-half the required load and then increased to the required load under which the height is to be measured. The spring shall not be rapped or otherwise disturbed during the test.

Physical Tests.

7. The physical properties of the springs shall be determined as follows:[1]

(*a*) *Loaded Height.*—The loaded height is the height when the specified normal load is applied after the maximum test load as defined in Section 5 (*e*) has been applied and fully released three times. The loaded height in the case of pleasure

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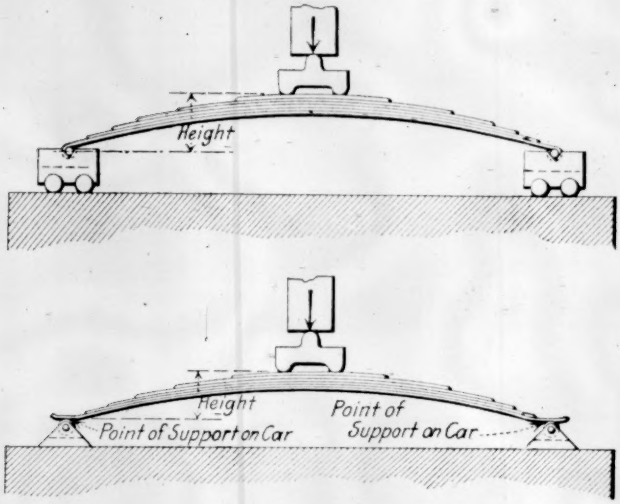
[1] See Section 13, "Appendix," for a convenient routine of tests.


Height
Height
Point of Support on Car
Point of Support on Car

FIGS. 1 AND 2.—Half-Elliptic Spring Compression Test Support.

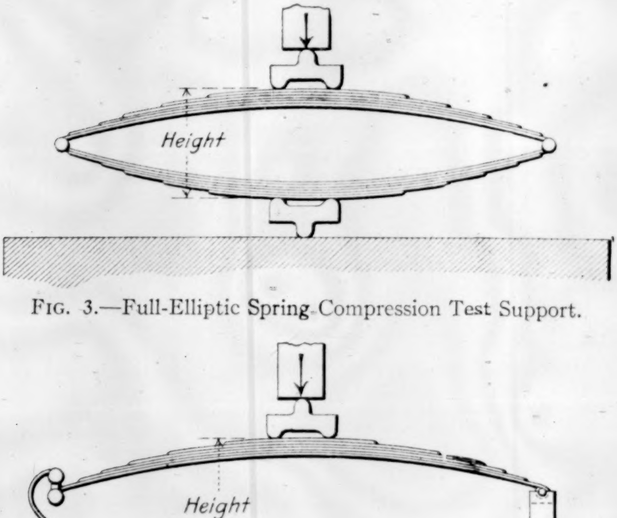


FIG. 3.—Full-Elliptic Spring Compression Test Support.

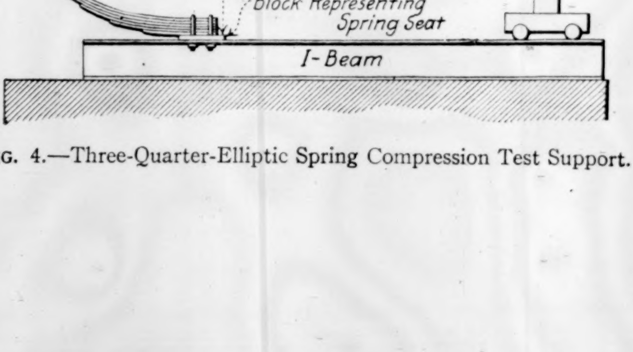
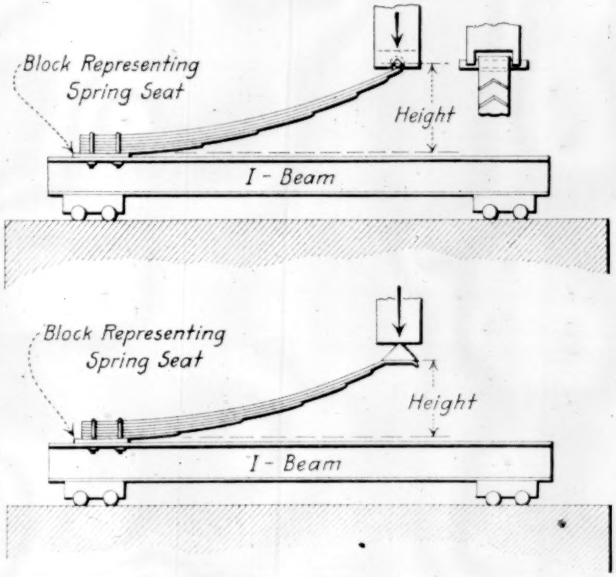

Height
Block Representing Spring Seat
I-Beam

FIG. 4.—Three-Quarter-Elliptic Spring Compression Test Support.

cars, unless otherwise specified, shall not be less, but may be $\frac{1}{4}$ in. and $\frac{3}{8}$ in. more than that specified for front and rear springs, respectively.


Block Representing
Spring Seat
Height
I - Beam
Block Representing
Spring Seat
Height
I - Beam

FIGS. 5 AND 6.—One-Quarter-Elliptic Spring Compression Test Support.

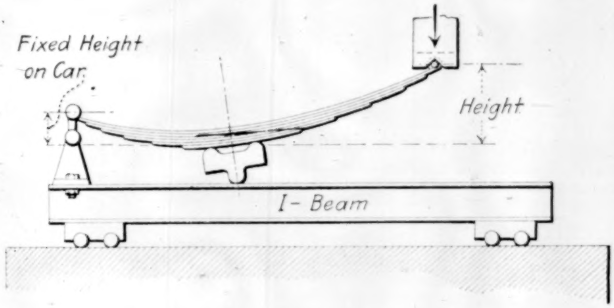

Fixed Height
on Car
Height
I - Beam

FIG. 7.—Half-Elliptic Cantilever Spring Compression Test Support.

(*b*) *Permanent Set.*—The permanent set is the difference, if any, between two successive measurements of the height under a load equal to 75 per cent of the specified normal load.

This load shall be applied for the first time after the maximum test load has been applied and fully released three times, and for the second time after the maximum test load has been applied again and fully released. The following two requirements shall be met:

(1) The permanent set shall not exceed $\frac{1}{16}$ in.;

(2) If there is any permanent set not exceeding $\frac{1}{16}$ in., the maximum test load shall be applied and fully released two additional times and a load equal to 75 per cent of the specified normal load applied a third time. The height under this third application shall not be less than that measured under the second application.

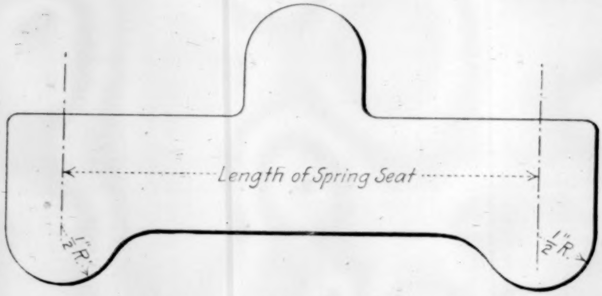


FIG. 8.—Pressure Block for Testing Springs.

(*c*) *Flexibility.*—The flexibility, when specified, shall be expressed in pounds per inch of deflection. It shall be determined by measuring the height under 75 per cent of the specified normal load and the height under 125 per cent of that load, and dividing the difference in loads by the difference in heights. The quotient is the flexibility in pounds per inch of deflection and shall not vary from that specified more than 5 per cent.

IV. MARKING.

Marking. 8. (*a*) The name or brand of the manufacturer, the year and month of manufacture, and if specified, the purchaser's class or part number, shall be legibly stamped on each spring at a place not detrimental to the life or service of the spring, on the exposed end of the compression side of a plate.

(*b*) Any stamping by the inspector shall be so placed as not to be detrimental to the life or service of the spring.

V. INSPECTION AND REJECTION.

Inspection. 9. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the springs ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the springs are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 10. Unless otherwise specified, any rejection based on tests made in accordance with Section 2 shall be reported within five working days from the receipt of samples.

Rehearing. 11. Samples tested in accordance with Section 2, which represent rejected springs, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

Reworking. 12. Any springs which fail to meet the requirements as to dimensions or physical tests may be again submitted after being remade by the manufacturer, such remaking to consist of insertion of new plates or of annealing, reforming and retreating of old plates. No springs shall contain cold reworked plates.

APPENDIX.

Recommended Routine for Testing.

Routine for Testing.

13. The physical tests required by Section 7 for the determination of loaded height, permanent set, and flexibility, can be carried out with the least possible number of operations by using the following routine of loading and measuring:

(1) Apply the maximum test load as defined in Section 6 (*e*) and release fully. Repeat this operation twice.

(2) Apply 75 per cent of the specified normal load, and measure the height (denote by h_1). This height is the first measurement for permanent set and for flexibility.

(3) Apply the specified normal load and measure the height (denote by h_2). This is the loaded height.

(4) Apply 125 per cent of the specified normal load and measure the height (denote by h_3). This is the second measurement for flexibility.

(5) Apply the maximum test load and release fully.

(6) Apply 75 per cent of the specified normal load and measure the height (denote by h_4). This is the second measurement for permanent set. If h_4 is less than h_1 the difference is the permanent set. If the permanent set does not exceed $\frac{1}{16}$ in., the following operations are required:

(7) Apply the maximum test load and release fully. Repeat this operation once.

(8) Apply 75 per cent of the specified normal load, and measure the height (denote by h_5). This is the third measurement for permanent set

Then:—

Loaded Height $= h_2$.

Permanent Set $= h_1 - h_4$, and springs are rejected if this is more than $\frac{1}{16}$ in. or if h_5 is less than h_4.

$$\textit{Flexibility} = \frac{\frac{1}{2} \times \text{specified normal load}}{h_1 - h_3}$$

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TENTATIVE SPECIFICATIONS
FOR
BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE.[1]

Serial Designation: A 70 – 17 T.

The specifications for this material are issued under the fixed designation A 70; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917.

Grades.

1. These specifications cover two grades of steel for boilers for stationary service, namely, flange and firebox.

I. MANUFACTURE.

Process.

2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The steel shall conform to the following requirements as to chemical composition:

		FLANGE.	FIREBOX.	
Carbon	For Plates ¾ in. or under in thickness	.....	0.12 – 0.25	per cent
	For Plates over ¾ in. in thickness	.....	0.12 – 0.30	"
Manganese		0.30 – 0.60	0.30 – 0.60	"
Phosphorus	Acid	not over 0.05	not over 0.04	"
	Basic	" " 0.04	" " 0.035	"
Sulfur		" " 0.05	" " 0.04	"

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, University of Pennsylvania, Philadelphia, Pa.

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses. 5. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 6. (*a*) The material shall conform to the following requirements as to tensile properties:

	FLANGE AND FIREBOX.
Tensile strength, lb. per sq. in.	55 000 – 65 000
Yield point, min., " "	0.5 tens. str.
Elongation in 8 in., min., per cent (See Section 7)	$\frac{1\,500\,000}{\text{Tens. str.}}$

(*b*) The yield point shall be determined by the drop of the beam of the testing-machine.

Modifications in Elongation. 7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction of 0.5 from the percentages of elongation specified in Section 6 (*a*) shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*b*) For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

Bend Tests. 8. The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Homogeneity Tests. 9. For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:

The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $\frac{1}{16}$ in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about $\frac{1}{4}$ in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

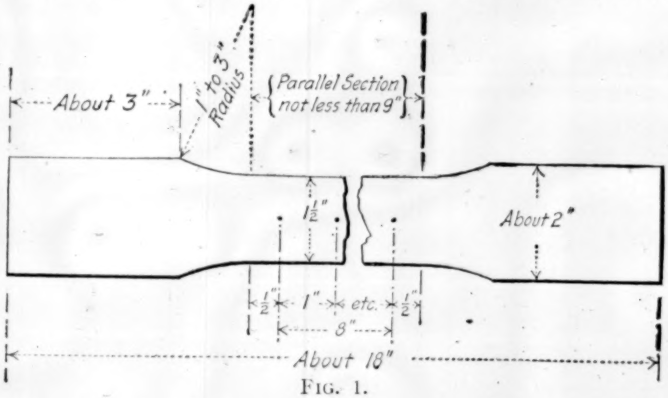

FIG. 1.

Test Specimens.

10. (*a*) Tension test specimens shall be taken longitudinally from the bottom of the finished rolled material, and bend test specimens shall be taken transversely from the middle of the top of the finished rolled material. The longitudinal test specimen shall be taken in the direction of the longitudinal axis of the ingot, and the transverse test specimen at right angles to that axis.

(*b*) Tension and bend test specimens shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

Number of Tests.

11. (*a*) One tension and one bend test shall be made from each plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variations.

12. *When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over.	
Under 1/8	9	10	12	14	..	..	..	..	..	Under 1/8
1/8 to 3/16 excl.	8	9	10	12	..	..	..	..	..	1/8 to 3/16 excl.
3/16 " 1/4 "	7	8	9	10	12	..	..	..	..	3/16 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

The overweight of each lot[1] in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

V. FINISH.

Finish.

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking.

14. (*a*) The name or brand of the manufacturer, melt or slab number, grade, and lowest tensile strength for its grade

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[1] The term "lot" applied to Table I means all of the plates of each group width and group thickness.

specified in Section 6 (*a*), shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen.

(*b*) When specified on the order, plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When more than one plate is sheared from a single slab or ingot, each shall be match-marked so that they may all be identified with the test specimens representing them.

(*c*) Each match mark shall consist of two over-lapping circles each not less than 1½ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

VII. INSPECTION AND REJECTION.

Inspection.

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5, shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
CARBON TOOL STEEL.[1]

Serial Designation: A 71 – 17 T.

The specifications for this material are issued under the fixed designation A 71; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Classes and Grades. 1. These specifications cover carbon tool steel in ten classes and three grades, determined by the chemical composition specified in Section 3.

I. MANUFACTURE.

Process. 2. The steel shall be made by the crucible or electric process, with the exception of Grade C, which may be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. C. L. Warwick, Secretary of Committee A-1 on Steel, University of Pennsylvania, Philadelphia, Pa.

ELEMENTS CONSIDERED.	CLASS NO.	GRADE A.	GRADE B.	GRADE C.
Carbon, per cent..........	1.............	0.45 - 0.60	(Same as Grade A)	(Same as Grade A)
	2.............	0.60 - 0.75		
	3.............	0.75 - 0.90		
	4.............	0.90 - 1.05		
	5.............	1.05 - 1.20		
	6.............	1.20 - 1.35		
	7.............	1.35 - 1.50		
	8.............	1.50 - 1.65		
	9.............	1.65 - 1.80		
	10.............	1.80 - 1.95		
Manganese, max., per cent....................		0.40	0.45	0.60
Phosphorus, max., per cent....................		0.02	0.025	0.035
Sulfur, max., per cent........................		0.02	0.035	0.04
Silicon, max., per cent.......................		0.35	0.35	0.25

Chemical Analyses. 4. In case of dispute, the chemical analyses shall be made in accordance with the Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33)[1] of the American Society for Testing Materials.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Permissible Variations. 5. The permissible variations in the size of the material ordered shall be agreed upon by the contractor and the purchaser.

IV. FINISH.

Finish. 6. The material shall be free from injurious defects, and shall have a workmanlike finish.

V. MARKING.

Marking. 7. The identification marks to be placed on the material shall be agreed upon by the contractor and the purchaser.

VI. INSPECTION AND REJECTION.

Inspection. 8. The contractor shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 9. Material which does not conform to the chemical composition and agreed variations, or which shows injurious defects, will be rejected, and the contractor shall be notified.

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[1] 1916 Book of A.S.T.M. Standards, p. 249.

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TENTATIVE SPECIFICATIONS FOR STAYBOLT IRON.[1]

Serial Designation: A 39 – 17 T.

The specifications for this material are issued under the fixed designation A 39; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Process. 1. The iron shall be rolled from a bloom, slabpile or boxpile, made wholly from reworked puddled pig iron or reworked knobbled charcoal iron. The puddle mixture and the component parts of the bloom, slabpile or boxpile shall be free from any admixture of iron scrap or steel.

Definition of Terms. 2. (*a*) *Bloom.*—A bloom is a solid mass of iron that has been hammered into a convenient size for rolling.

(*b*) *Slabpile.*—A slabpile is built up wholly of flat bars of iron of the full length of the pile.

(*c*) *Boxpile.*—A boxpile is a pile, the sides, top and bottom of which are formed by four flat bars and the interior of which consists of a number of small bars the full length of the pile.

(*d*) *Iron Scrap.*—This term applies only to foreign or bought scrap and does not include local mill products free from foreign or bought scrap.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. H. E. Smith, Chairman of Committee A-2 on Wrought Iron, Grand Central Terminal, New York City.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Staybolt Iron (A 39–14), 1916 Book of A.S.T.M. Standards, p. 315.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. At the option of the purchaser and when so specified, the iron shall conform to the following requirement as to chemical composition:

Manganese........................... not over 0.10 per cent

Check Analyses.

4. (*a*) An analysis may be made by the purchaser from a broken tension test specimen representing each lot as specified in Section 9 (*a*). The chemical composition thus determined shall conform to the requirements specified in Section 3.

(*b*) Drillings for chemical analysis shall be so taken as to represent the entire cross-section of the specimen.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

5. (*a*) The iron shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	48 000 – 52 000
Yield point, min., lb. per sq. in.	0.6 tens. str.
Elongation in 8 in., min., per cent	30
Reduction of area, min., per cent	48

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed $\frac{3}{4}$ in. per minute.

Cold-Bend Tests.

6. (*a*) The test specimen shall bend cold through 180 deg. flat on itself in both directions, without fracture on the outside of the bent portion.

(*b*) Bend tests may be made by pressure or by blows.

Etch Tests.[1]

7. The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to have been rolled from a bloom, slabpile or boxpile, and to be free from steel.

Test Specimens.

8. All test specimens shall be of the full section of material as rolled.

Number of Tests.

9. (*a*) Bars of one size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction

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[1] A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulfuric acid is recommended for the etch test.

thereof, and tested as specified in Sections 5 and 6; but only one of these bars shall be tested as specified in Sections 3 and 7.

(*b*) If any test specimen from either of the bars originally selected to represent a lot of material contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, the individual bar shall be rejected and one retest from a different bar will be allowed.

IV. PERMISSIBLE VARIATIONS IN GAGE.

Permissible Variations.

10. The bars shall be truly round within 0.01 in., and shall not vary more than 0.005 in. above nor more than 0.01 in. below the specified size.

V. FINISH.

Finish.

11. The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends, and evidences of being burnt.

VI. MARKING.

Marking.

12. The bars shall be stamped or marked as designed by the purchaser.

VII. INSPECTION AND REJECTION.

Inspection.

13. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

14. (*a*) If either of the test bars selected to represent a lot

does not conform to the requirements specified in Sections 3, 5, 6, 7 and 8, the lot will be rejected.

(*b*) Bars which will not take a clean, sharp thread with dies in fair condition, or which develop defects in forging or machining, will be rejected, and the manufacturer shall be notified.

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TENTATIVE SPECIFICATIONS
FOR
WROUGHT-IRON PIPE.[1]

Serial Designation: A 72 – 17 T.

The specifications for this material are issued under the fixed designation A 72; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Basis of Purchase.

1. (*a*) All pipe to be used on locomotives and cars shall be of coiling or bending quality.

(*b*) Unless otherwise specified on the purchase order, inspection and all tests except the hydrostatic pressure test shall be made by the purchaser at destination, and at his expense.

I. MANUFACTURE.

Process.

2. (*a*) The iron shall be made from muck bars, made from puddled pig iron, free from any admixture of iron scrap or steel.

(*b*) All pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. All pipe over 3 in. in nominal diameter shall be lap-welded.

Definition of Terms.

3. *Iron Scrap.*—This term applies only to foreign or bought scrap and does not include local mill products, free from foreign or bought scrap.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. H. E. Smith, Chairman of Committee A-2 on Wrought Iron, Grand Central Terminal, New York City.

These specifications, when adopted as standard, will supersede the requirements for wrought-iron pipe in the present Standard Specifications for Welded Steel and Wrought-Iron Pipe (A 53–15), 1916 Book of A.S.T.M. Standards, p. 215.

II. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

4. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	40 000
Yield point, lb. per sq. in.	24 000
Elongation in 8 in., per cent	12

TABLE I.—HYDROSTATIC PRESSURES FOR WELDED PIPE.

(PRESSURE EXPRESSED IN POUNDS PER SQUARE INCH.)

Inside Diameter, in.	Standard-Grade Pipe.		Extra-Strong Pipe.	
	Butt-Weld.	Lap-Weld.	Butt-Weld.	Lap-Weld.
$\frac{1}{8}$	700	....	700	....
$\frac{1}{4}$	700	....	700	....
$\frac{3}{8}$	700	....	700	....
$\frac{1}{2}$	700	....	700	....
$\frac{3}{4}$	700	....	700	....
1	700	....	700	....
$1\frac{1}{4}$	700	1000	1500	2500
$1\frac{1}{2}$	700	1000	1500	2500
2	700	1000	1500	2500
$2\frac{1}{2}$	800	1000	1500	2000
3	800	1000	1500	2000
$3\frac{1}{2}$	...	1000	....	2000
4	...	1000	....	2000
$4\frac{1}{2}$	...	1000	....	1800
5	...	1000	....	1800
6	...	1000	....	1800

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the crosshead of the machine shall not exceed $\frac{3}{4}$ in. per minute.

Hydrostatic Tests.

5. All pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

Fracture Test.

6. A section of pipe 6 in. in length shall be flattened until broken by repeated light blows of a hammer or by pressure; the fracture developed shall have a fibrous appearance.

Bend Test. 7. For sizes 2 in. and under, a sufficient length of coiling or bending pipe shall bend cold through 90 deg. around a cylindrical mandrel, the diameter of which is 15 times the nominal diameter of the pipe, without developing cracks at any portion and without opening at the weld.

Test Specimens. 8. (*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(*b*) Tension test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

Number of Tests. 9. One of each of the tests specified in Sections 4, 6 and 7, may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

Retests. 10. If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 and 7, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

III. STANDARD WEIGHTS.

Standard Weights. 11. (*a*) The standard weights for pipe of various inside diameters are given in Table II.

(*b*) Nipples shall be cut from pipe of the same weight and quality as described in these specifications.

Permissible Variations. 12. The weight of the pipe shall not vary more than 5 per cent from that specified in Section 11 (*a*).

IV. WORKMANSHIP AND FINISH.

Workmanship. 13. (*a*) For pipe $1\frac{1}{2}$ in. or under, the outside diameter, at any point, shall not vary more than $\frac{1}{64}$ in. over nor more than $\frac{1}{32}$ in. under the standard. For pipe 2 to 6 in., inclusive, the outside diameter shall not vary more than 1 per cent over nor more than $\frac{3}{64}$ in. under the standard.

(*b*) All standard-weight pipe shall be provided with the prevailing standard thread, which will make a tight joint when tested to the internal hydrostatic pressure at the mill. The threads shall not vary more than one and one-half turns either way, when tested with a Pratt & Whitney standard gage. All burrs at the end of the pipe shall be removed.

(*c*) Unless otherwise ordered, pipe shall be furnished in random lengths of 16 to 22 ft., but not more than 5 per cent of the total number of lengths furnished may be "jointers," which are two pieces coupled together. When ordered with plain ends, 5 per cent may be furnished in lengths of 12 ft. or over.

TABLE II.—STANDARD WEIGHTS.

(ALL DIMENSIONS ARE NOMINAL.)

Dimensions.			Standard-Grade Pipe.	Extra-Strong Pipe.
Inside Diameter, in.	Number of Threads per Inch.	Outside Diameter, in.	Weight of Pipe per Linear Foot, Threaded and with Couplings, lb.	Weight of Pipe per Linear Foot, Plain Ends, lb.
$\frac{1}{8}$	27	0.405	0.25	0.31
$\frac{1}{4}$	18	0.540	0.43	0.54
$\frac{3}{8}$	18	0.675	0.57	0.74
$\frac{1}{2}$	14	0.840	0.85	1.09
$\frac{3}{4}$	14	1.050	1.13	1.47
1	$11\frac{1}{2}$	1.315	1.68	2.17
$1\frac{1}{4}$	$11\frac{1}{2}$	1.660	2.28	3.00
$1\frac{1}{2}$	$11\frac{1}{2}$	1.900	2.73	3.63
2	$11\frac{1}{2}$	2.375	3.68	5.02
$2\frac{1}{2}$	8	2.875	5.82	7.66
3	8	3.500	7.62	10.25
$3\frac{1}{2}$	8	4.000	9.20	12.51
4	8	4.500	10.89	14.98
$4\frac{1}{2}$	8	5.000	12.64	17.61
5	8	5.563	14.81	20.78
6	8	6.625	19.19	28.57

(*c*) Each standard weight pipe shall be provided with a coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings shall be of wrought iron.

(*d*) Unless otherwise specified, extra-strong pipe shall be furnished in random lengths, with plain ends.

14 The finished pipe shall be reasonably straight and free from injurious defects. **Finish.**

V. INSPECTION AND REJECTION.

Inspection. 15. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the pipe are being furnished in accordance with these specifications.

(*b*) When tests and inspection are made at the place of manufacture, they shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. Pipe which develop injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

Rehearing. 17. Samples tested in accordance with Section 1 (*b*), which represent rejected pipe, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
WROUGHT-IRON ROLLED OR FORGED BLOOMS AND FORGINGS FOR LOCOMOTIVES AND CARS.[1]

Serial Designation: A 73 – 17 T.

The specifications for this material are issued under the fixed designation A 73; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

1. These specifications cover two classes of blooms and forgings as determined by the kind of material used in their manufacture, as follows: **Classes.**

Class A, as defined in Section 2 (*a*);
Class B, as defined in Section 2 (*b*).

I. MANUFACTURE.

2. (*a*) *Class A*.—Blooms and forgings of class A shall be made wholly from puddled pig iron. The puddle mixture and the component parts of the piles from which the blooms and forgings are made, shall be free from any admixture of iron scrap or steel. The term "iron scrap" applies only to foreign or bought scrap, and does not include the producers' own scrap from the same product and of equal quality. **Material.**

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. H. E. Smith, Chairman of Committee A-2 on Wrought Iron, Grand Central Terminal, New York City.

(*b*) *Class B.*—Blooms and forgings of class B shall be made from selected No. 1 wrought-iron scrap, or a mixture of such scrap and the puddled iron described in Section 2 (*a*).

Process.

3. In both classes of forgings, cross piling is prohibited. In the final pile for the bloom or forging, all bars and slabs shall be of the full length of the pile.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. (*a*) The iron shall conform to the following requirements as to chemical composition:

	CLASS A	CLASS B
Manganese, max., per cent	0.07	0.15

(*b*) An analysis may be made by the purchaser from each specimen used for the tension test. The drillings or chips taken for analysis shall represent the full cross-section of the test specimen.

III. PHYSICAL PROPERTIES AND TESTS.

Tensile Tests.

5. (*a*) The iron shall conform to the following requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	45 000
Yield point, min., lb. per sq. in.	0.5 tens. str.
Elongation in 4 in., min., per cent	22
Reduction of area, min., per cent	30

The fracture shall be free from crystallization.

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed $\frac{3}{8}$ in. per minute.

Etching Test.

6. The entire cross-section of the prolongation of the bloom or forging shall be ground or polished, and shall show no seams or flaws of injurious character. It shall then be etched and, in class A material, shall show freedom from steel.

Test Specimens.

7. All tension test specimens shall be taken from a full-size prolongation of the bloom or forging, the axis of the specimen being parallel to the axis of the bloom or forging and midway between its center and outside. They shall be turned to a reduced cross-section $\frac{7}{8}$ in. in diameter and shall be $4\frac{1}{4}$ in. long between fillets. The ends of the test specimens may be of any form which will fit the holders of the testing machine.

8. The number of tests and retests, if necessary, shall be agreed on between the manufacturer and purchaser. **Number of Tests.**

IV. WORKMANSHIP AND FINISH.

9. The blooms and forgings shall be in accordance with drawings furnished by the purchaser. **Workmanship.**

10. The blooms and forgings shall be free from injurious seams, cracks, evidence of overheating and other defects. **Finish.**

V. INSPECTION AND REJECTION.

11. (*a*) The inspector representing the purchaser shall have free entry, at all time while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment. **Inspection.**

(*b*) The purchaser may take the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expenses of the purchaser.

(*c*) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

12. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 (*b*) shall be reported within five working days from the receipt of samples. **Rejection.**

(*b*) Blooms and forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

13. Samples tested in accordance with Section 4 (*b*) which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests the manufacturer may make claim for a rehearing within that time. **Rehearing.**

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TENTATIVE SPECIFICATIONS
FOR
CAST-IRON SOIL PIPE AND FITTINGS.[1]

Serial Designation: A 74 – 17 T.

The specifications for this material are issued under the fixed designation A 74; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Cast Iron. 1. The cast iron from which the pipe and fittings are made shall be of such composition, and the conditions of manufacture so maintained, that the castings will be of uniform physical character, close-grain, not hard, brittle nor difficult to cut with file or chisel.

Coating for Cast Iron. 2. (*a*) When pipe or fittings are to be coated, coal-tar pitch shall be used, which shall contain sufficient oil to make a smooth coating. The pitch shall be tough and tenacious when cold, and not brittle nor having any tendency to scale.

(*b*) The varnish shall be heated to about 300° F. and shall remain at this temperature during the time the casting is immersed.

(*c*) Each casting shall be heated to a uniform temperature of about 300° F. immediately before it is dipped, and shall possess this temperature at the time it is put in the bath.

(*d*) Each casting shall remain in the bath at least two minutes.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Richard Moldenke, Chairman of Committee A-3 on Cast Iron, Watchung, N. J.

(*e*) Fresh pitch and oil shall be added when necessary to keep the mixture of the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch whenever the accumulation of sand or carbonaceous matter renders this desirable, as can be seen by the adhering solids to the under side or lower ends of the castings.

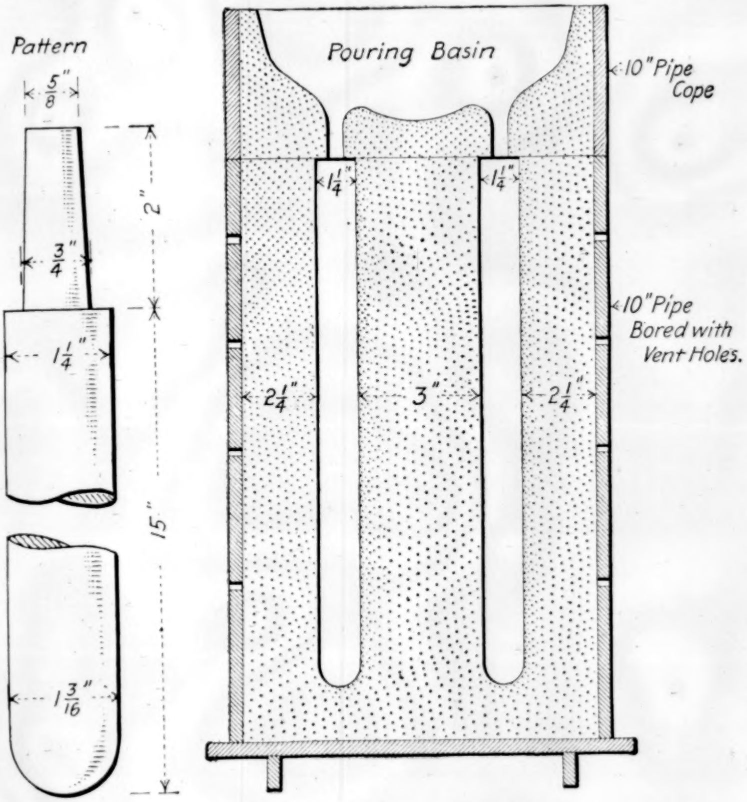
Pattern
5/8"
3/4"
1 1/4"
1 3/16"
2"
15"
Pouring Basin
10" Pipe Cope
1 1/4"
1 1/4"
10" Pipe Bored with Vent Holes.
2 1/4"
3"
2 1/4"

FIG. 1.—Mold for Arbitration Test Bar.

(*f*) After being coated the pipe and fittings shall be carefully drained of the surplus varnish.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. Drillings taken from the fractured end of the arbitration test bar shall not contain over 0.10 per cent of sulfur.

III. PHYSICAL PROPERTIES AND TESTS.

Number of Specimens. 4. From each melt of metal not less than three test specimens shall be poured, the first of which shall be poured within five minutes after the first ladle is tapped and the remainder at intervals not exceeding one hour throughout the melt.

Mold for Test Specimens. 5. The mold for the arbitration bars is shown in Fig. 1. The bottom of the bar is $\frac{1}{16}$ in. smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of one to twelve bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply brushed off before testing.

Transverse Test. 6. When placed horizontally upon supports 12 in. apart and tested under a centrally applied load, the arbitration test bars, specified in Section 5, shall show a transverse strength of not less than 2500 lb., and the deflection shall not be less than 0.1 in.

Hydrostatic Test. 7. All pipe shall be tested to a hydrostatic pressure of not less than 50 lb. per sq. in. before coating. Any casting showing defects under this hydrostatic test shall be promptly broken and returned to the cupola.

IV. STANDARD SIZES AND WEIGHTS.

Diameter of Pipe. 8. (*a*) The inside diameter of the barrel of any pipe or fittings or branch thereof shall not vary more than $\frac{1}{8}$ in. under the nominal size of pipe.

(*b*) The outside diameter of the barrel of pipe and fittings shall be $\frac{1}{2}$ in. greater than its nominal inside diameter. A variation in the outside diameter of $\frac{1}{8}$ in. over or under these figures will be permitted.

(*c*) All pipe and fittings shall be of uniform thickness of wall and present true circles at the hub and spigot ends. A variation of $\frac{1}{16}$ in. under the following dimensions will be permitted, but only when the actual weight is not less than the variation of the marked or estimated weight as given in Tables I and II:

Thickness of barrel	$\frac{1}{4}$ in.
" " body of hub	$\frac{5}{16}$ "
" " bead " "	$\frac{1}{2}$ "
" " " " spigot end	$\frac{7}{16}$ "

Weight.

9. (*a*) Weights and measurements of pipe and fittings shall be taken as those of plain uncoated pipe. All weights shall be given in pounds.

(*b*) Individual lengths of pipe and fittings may weigh 5 per cent less than designated in Tables I and II, but only when the average weight of a given size and weight of pipe and fittings selected at random, is not less than that shown in Tables I and II.

(*c*) The regular length of pipe shall be such as to lay 5 ft. including hub.

(*d*) The average weights of soil pipe and fittings shall not be less than those given in Tables I and II.

TABLE I.—WEIGHTS OF SOIL PIPE.

Size, in.	Single Hub.		Double Hub.
	Per 5-ft. Length, lb.	Per ft. Including Hub, lb.	Per 5-ft. Length, lb.
2	27½	5½	27½
3	47½	9½	47½
4	65	13	65
5	85	17	85
6	100	20	100

V. WORKMANSHIP AND FINISH.

Character of Castings.

10. (*a*) All pipe and fittings shall be practically straight and cylindrical and fittings true to pattern. The specified sizes shall be for the inside diameter and shall conform, within the allowable variation, to the dimensions given in the tables.

(*b*) All pipe and fittings shall be carefully examined for defects and sounded with a hammer before shipment. No fillings with metal, cement or other material, or so-called burning on of iron will be permitted. The castings shall be sound and free from cracks, sand-holes, blow-holes and cold-shots.

VI. MARKING.

Marking. 11. All pipe and fittings shall be marked with the manufacturer's name or appropriate initial. Every casting shall have cast upon it the minimum or estimated weight of same as shown in Tables I and II.

Table II.—Weights of Soil Pipe Fittings.

Only the Staple Fittings are Shown. From the Data Herewith the Weights of Other Fittings may be Calculated.

All values are in pounds.

Fittings.	Size of Fittings, in.													
	2	3	4	5	6	3 by 2	4 by 2	4 by 3	5 by 2	5 by 3	5 by 4	6 by 2	6 by 3	6 by 4	6 by 5
$\frac{1}{4}$ Bends, regular	$6\frac{3}{4}$	$10\frac{1}{4}$	15	19	$23\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
$\frac{1}{4}$ Bends, short sweep	$8\frac{1}{4}$	$12\frac{1}{2}$	$17\frac{3}{4}$	$22\frac{1}{2}$	$27\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
$\frac{1}{4}$ Bends, long sweep	$10\frac{1}{4}$	$15\frac{3}{4}$	22	$27\frac{1}{2}$	$33\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
$\frac{1}{5}$ Bends	$6\frac{1}{4}$	$9\frac{3}{4}$	$13\frac{3}{4}$	$17\frac{1}{2}$	$21\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
$\frac{1}{6}$ Bends	6	$9\frac{1}{4}$	13	$16\frac{1}{2}$	20	....	....	....	....	....	....	....	....	....	....
$\frac{1}{8}$ Bends	$5\frac{1}{2}$	$8\frac{1}{2}$	$12\frac{1}{4}$	$15\frac{1}{4}$	$18\frac{1}{4}$	....	....	....	....	....	....	....	....	....	....
$\frac{1}{16}$ Bends	5	$7\frac{3}{4}$	$10\frac{3}{4}$	$13\frac{1}{4}$	$15\frac{3}{4}$	....	....	....	....	....	....	....	....	....	....
Return Bends	$8\frac{3}{4}$	14	$20\frac{1}{4}$	$26\frac{1}{2}$	$33\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
Tees	$10\frac{1}{4}$	$15\frac{1}{4}$	21	$26\frac{1}{2}$	$32\frac{1}{2}$	$13\frac{1}{4}$	$16\frac{1}{2}$	$18\frac{3}{4}$	$19\frac{1}{4}$	22	$24\frac{1}{2}$	$22\frac{1}{2}$	25	$27\frac{1}{2}$	30
Tapped Tees (tapped up to 2 in.)	$8\frac{3}{4}$	....	....	....	....	$11\frac{3}{4}$	15	....	$17\frac{3}{4}$	....	....	$20\frac{1}{2}$	....	....	....
Sanitary Tees	11	$16\frac{1}{4}$	$22\frac{1}{2}$	28	$34\frac{1}{2}$	14	$17\frac{1}{4}$	$19\frac{3}{4}$	20	23	$25\frac{1}{2}$	23	26	29	$31\frac{1}{2}$
Tapped Sanitary Tees (tapped up to 2 in.)	9	....	....	....	....	12	$15\frac{1}{4}$	....	18	....	....	$21\frac{1}{4}$	....	....	....
Y Branch	11	17	24	$31\frac{1}{2}$	$39\frac{1}{2}$	14	$17\frac{1}{4}$	$20\frac{1}{2}$	20	$23\frac{1}{2}$	$27\frac{1}{2}$	23	27	31	35
$\frac{1}{2}$ Y Branch	$10\frac{1}{4}$	$15\frac{1}{2}$	$21\frac{1}{2}$	$27\frac{1}{2}$	34	$13\frac{1}{2}$	$16\frac{1}{2}$	19	$19\frac{1}{2}$	22	25	$22\frac{1}{2}$	$25\frac{1}{2}$	$28\frac{1}{2}$	31
Tapped Inverted Y Branch (tapped up to 2 in.)	$10\frac{1}{4}$	$13\frac{3}{4}$	$17\frac{1}{2}$	21	24	....	....	....	....	....	....	....	....	....	....
Inverted Y Branch	$11\frac{1}{2}$	18	$25\frac{1}{2}$	33	$41\frac{1}{2}$	15	$18\frac{3}{4}$	22	22	$25\frac{1}{2}$	$29\frac{1}{2}$	$25\frac{1}{2}$	$29\frac{1}{2}$	33	37
Combination Y and $\frac{1}{8}$ Bend	12	$18\frac{3}{4}$	27	35	$44\frac{1}{2}$	15	$18\frac{1}{4}$	$22\frac{1}{2}$	21	$25\frac{1}{2}$	$30\frac{1}{2}$	24	29	34	39
Upright Y Branch	$12\frac{1}{2}$	$19\frac{1}{2}$	28	$36\frac{1}{2}$	46	$15\frac{3}{4}$	$18\frac{3}{4}$	23	$21\frac{1}{2}$	$26\frac{1}{2}$	$31\frac{1}{2}$	$24\frac{1}{2}$	$29\frac{1}{2}$	35	40

VII. INSPECTION AND REJECTION.

Inspection. 12. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works, and shall be made prior to shipment, unless otherwise specified.

13. All pipe and fittings which fail to conform to the provisions of these specifications shall be subject to rejection. **Rejection.**

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PHILADELPHIA, PA., U. S. A.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
RAILROAD MALLEABLE-IRON CASTINGS.[1]

Serial Designation: A 75 – 17 T.

The specifications for this material are issued under the fixed designation A 75; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Process. 1. The castings shall be produced by either the air-furnace, open-hearth or electric-furnace process.

II. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 2. Tension test specimens specified in Section 5 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	45 000
Elongation in 2 in., per cent	7.5

Transverse Tests. 3. Transverse test specimens specified in Section 5, tested with the cope side up on supports 12 in. apart, pressure being applied at the center, shall sustain a load not less than 2100 lb., and show a minimum deflection of 1.125 in.

Special Tests. 4. In the case of castings of special design and importance, test lugs shall be cast of a size proportional to the thickness of the casting but not exceeding $\frac{5}{8}$ by $\frac{3}{4}$ in. in cross-section. On castings which are 24 in. or over in length, a test lug shall be cast at each end. These test lugs shall be attached to the casting at such point that they will not interfere with the assembling of the casting and may be broken off by the inspector. If the purchaser or his representative so desires, a casting may be tested to destruction. Such a casting shall show good, tough malleable iron.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Richard Moldenke, Chairman of Committee A-3 on Cast Iron, Watchung, N. J.

Test Specimens. 5. (*a*) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Specimens whose mean diameter at the smallest section is less than $\frac{19}{32}$ in. will not be accepted for test.

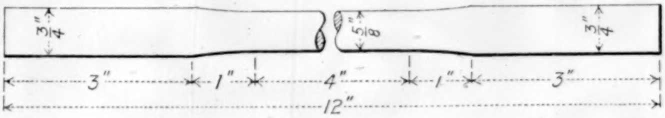

FIG. 1.

(*b*) Transverse test specimens shall be 14 in. in length, 1 in. in width and $\frac{3}{4}$ in. in thickness, and shall not vary more than $\frac{1}{32}$ in. in either sectional dimension. Before the test is made, the specimen shall be center punched in accordance with Fig. 2, and after test, the deflection shall be measured as shown.

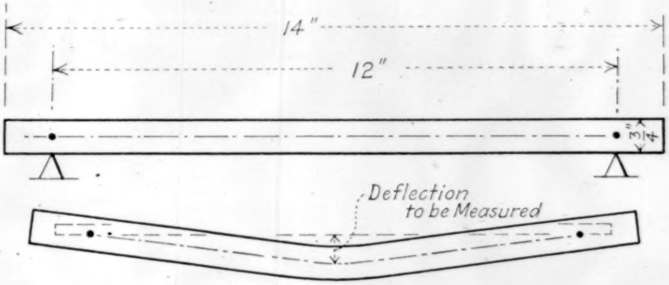

FIG. 2.

(*c*) Two tension and two transverse test specimens shall be cast from each melt, without the use of chills, with risers of sufficient height at each end to insure sound bars. These bars, representing the castings from each heat, shall be suitably marked to insure identification and annealed with the castings.

Number of Tests. 6. One tension and one transverse test specimen representing each melt shall be selected for test. The remaining specimens shall be reserved and shall be tested in case of failure of the first test to conform to the requirements specified.

Requirements. 7. If more than one tension or transverse test specimen fails to meet the requirements as to tensile or transverse properties specified in Sections 2 and 3, the castings from that melt shall be rejected.

III. WORKMANSHIP AND FINISH.

Workmanship. 8. The castings shall conform substantially to the patterns or drawings furnished by the purchaser, and also to gages which may be specified in individual cases. They shall be made in a workmanlike manner. A variation of $\frac{1}{8}$ in. per ft. will be permitted.

Finish. 9. The castings shall be free from injurious defects.

IV. MARKING.

Marking. 10. All castings shall have cast on them the manufacturer's identification mark and the pattern number assigned by the purchaser, these markings being applied at such a point that they will not interfere with the service of the castings.

V. INSPECTION AND REJECTION.

Inspection. 11. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise ordered by the purchaser, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The manufacturer shall be required to keep a record of each melt from which castings are produced, showing tensile strength and elongation of test bars cast from such melts. These records shall be available and shown to the inspector whenever required.

Rejection. 12. Castings which show injurious defects subsequent to their acceptance at the manufacturer's works may be rejected, and, if rejected, shall be replaced by the manufacturer free of charge to the purchaser.

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TENTATIVE SPECIFICATIONS
FOR
THE ALLOY; COPPER, 88 PER CENT; TIN, 10 PER CENT; ZINC, 2 PER CENT.[1]

Serial Designation: B 10 – 15 T.

The specifications for this material are issued under the fixed designation B 10; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915.

Scope.

1. (*a*) These specifications cover the alloy commercially known as government bronze, admiralty gun-metal, gun-metal, or 88–10–2 mixture, when used in castings.

(*b*) It is recommended that this alloy shall not be used where castings are subjected to a temperature exceeding 260° C. (500° F.).

I. MANUFACTURE.

Process.

2. The alloy may be made by any approved method.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The alloy shall conform to the following requirements as to chemical composition:

Copper	86–89 per cent.
Tin	8–11 "
Zinc	1– 3 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Sampling. 4. (*a*) The sample for chemical analysis may be taken either by sawing, drilling or milling the casting or tension test specimen and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation and the saw dust or metal chips shall be carefully treated with a magnet to remove any particles of iron derived from the tools.

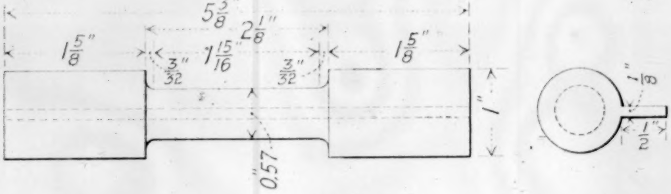

FIG. 1.

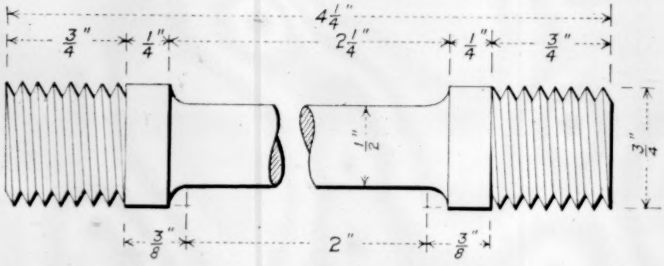

FIG. 2.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 5. The alloy shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	33 000
Elongation in 2 in., per cent	14

Test Specimens. 6. (*a*) Two test bars of the form and dimensions shown in Fig. 1 shall be an integral part of large castings, or cast separately in the case of small castings to represent a lot or melt and shall be molded in a manner similar to the castings which they represent. If the castings are heat-treated, the test bars representing such castings shall be similarly heat-treated.

(*b*) The manufacturer and purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are to be attached, and on the method of casting unattached bars. Unless otherwise agreed upon, the minimum lot shall be considered as 500 lb.

(*c*) The tension test specimen, turned down from the test bar shown in Fig. 1, shall be of the form and dimensions shown in Fig. 2.

Number of Tests.

7. (*a*) Two tension tests shall be made from each lot or melt.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

IV. INVESTIGATION OF CLAIMS.

Investigation of Claims.

8. If the purchaser's tests show that the material does not conform to the requirements specified in Section 3, the manufacturer shall have the opportunity to inspect the material and each party shall select a sample for retest. If the results do not agree, they shall select the sample to be sent to a mutually agreeable umpire, whose decision shall be final. The costs of retests shall be paid by the loser.

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TENTATIVE SPECIFICATIONS
FOR
COPPER PLATES FOR LOCOMOTIVE FIREBOXES.[1]

Serial Designation: B 11 – 16 T.

The specifications for this material are issued under the fixed designation B 11; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Grades. 1. These specifications cover two grades of copper for locomotive fireboxes, namely, Arsenical and Non-Arsenical.

I. MANUFACTURE.

Process. 2. The copper shall be fire-refined or electrolytic, and hot rolled from suitable cakes.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The copper shall conform to the following requirements as to chemical composition:

(*a*) *Arsenical Copper.*—Arsenical copper shall contain 0.25 to 0.50 per cent of arsenic, and shall not contain more than 0.120 per cent of impurities, exclusive of arsenic and silver.

(*b*) *Non-Arsenical Copper.*—Non-Arsenical copper shall have a purity of at least 99.880 per cent, as determined by electrolytic assay, silver being counted as copper. The total of impurities other than silver shall not exceed 0.120 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Chemical Analyses. 4. Analyses may be made by the purchaser from a broken tension test specimen representing each plate as rolled, which shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 5. The material shall conform to the following requirements as to tensile properties:

	ARSENICAL.	NON-ARSENICAL.
Tensile strength, lb. per sq. in..........	not under 31 000	not under 30 000
Elongation in 8 in., min., per cent......	35	30

Bend Tests. 6. The specimen shall bend both hot (500 to 700° C.) and cold 180 deg. without cracking on the outside of the bent portion as follows: For material 1 in. or under in thickness, flat on itself; and for material over 1 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

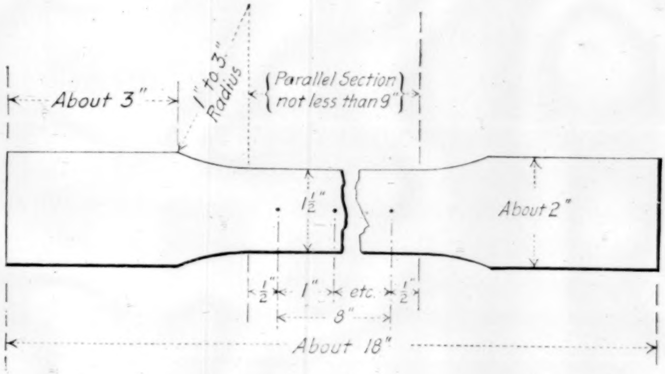

FIG. 1.

Test Specimens. 7. Tension and bend test specimens shall be taken from the finished rolled material. They shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

Number of Tests. 8. (*a*) One tension, one cold-bend and one hot-bend test shall be made from each plate as rolled.

(*b*) If any test specimen develops flaws it may be discarded and two other specimens substituted, both of which shall be free from flaws. If flaws appear in either or both of the substituted specimens the lot shall be rejected.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(*d*) If any test specimen shows defective machining it may be discarded and another specimen substituted.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

ORDERED THICKNESS, IN.	WEIGHT, LB. PER SQ. FT.	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, Expressed in Percentages of Nominal Weights.			
		Under 75 in.	75 to 100 in., excl.	100 to 115 in., excl.	115 in. or over.
$\frac{5}{16}$	14.53	8	12	16	..
$\frac{3}{8}$	17.44	7	10	13	17
$\frac{7}{16}$	20.34	6	8	10	13
$\frac{1}{2}$	23.25	5	7	9	12
$\frac{9}{16}$	26.16	5	6.5	8.5	11
$\frac{5}{8}$	29.06	5	6	8	10
Over $\frac{5}{8}$	.....	5	5	6.5	9

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variations.

9. *When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.04 in. under that ordered. An excess over the nominal weight corresponding to the dimensions on the order shall be allowed for each plate if not more than that shown in Table I, one cubic inch of rolled copper being assumed to weigh 0.323 lb.

V. FINISH.

Finish.

10. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking. 11. The name or brand of the manufacturer, plate number, and grade shall be stamped on each plate. The plate number shall be legibly stamped on each test specimen.

VII. INSPECTION AND REJECTION.

Inspection. 12. The manufacturer shall afford the inspector free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. (*a*) Unless otherwise specified, any rejection based on chemical and physical tests made in accordance with these specifications shall be reported within five working days from the receipt of samples.

(*b*) Material which, subsequent to its acceptance at the manufacturer's works, is shown to have contained injurious defects will be rejected, and the manufacturer shall be notified.

Rehearing. 14. Samples tested in accordance with Section 4, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
COPPER BARS FOR LOCOMOTIVE STAYBOLTS.[1]

Serial Designation: B 12 – 16 T.

The specifications for this material are issued under the fixed designation B 12; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Grades. 1. These specifications cover two grades of copper for locomotive staybolts, namely, Arsenical and Non-Arsenical.

I. MANUFACTURE.

Process. 2. The copper shall be fire-refined or electrolytic and shall be finished to dimensions by hot rolling from suitable bars.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The copper shall conform to the following requirements as to chemical composition:

(*a*) *Arsenical Copper.*—Arsenical copper shall contain 0.25 to 0.50 per cent of arsenic, and shall contain not more than 0.120 per cent of impurities exclusive of arsenic and silver.

(*b*) *Non-Arsenical Copper.*—Non-Arsenical copper shall have a purity of at least 99.880 per cent, as determined by electrolytic assay, silver being counted as copper. The total of impurities other than silver shall not exceed 0.120 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Chemical Analyses. 4. An analysis may be made from one sample for each 5000 lb. or fraction thereof of finished bars, and such analyses shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 5. The material shall conform to the following requirements as to tensile properties:

	ARSENICAL.	NON-ARSENICAL.
Tensile strength, lb. per sq. in..........	not under 31 000	not under 30 000
Elongation in 8 in., min., per cent......	35	30

Bend Tests. 6. The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens. 7. Bend test specimens shall be of the full-size section of bars as rolled.

Number of Tests. 8. (*a*) One tension and one bend test shall be made from each 5000 lb. (or fraction).

(*b*) If any test specimen develops flaws it may be discarded and two other specimens substituted, both of which shall be free from flaws. If flaws appear in either or both of the substituted specimens the lot shall be rejected.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5, and any part of the fracture is outside the middle third of gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(*d*) If any test specimen shows defective machining it may be discarded and another specimen substituted.

IV. PERMISSIBLE VARIATION IN GAGE.

Permissible Variations. 9. The bars shall be truly round within 0.01 in., and shall not vary more than 0.005 in. over nor more than 0.01 in. under the specified size.

V. WORKMANSHIP AND FINISH.

Finish. 10. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking. 11. The finished bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the lot number for identification. The lot number shall be legibly marked on each test specimen.

VII. INSPECTION AND REJECTION.

Inspection. 12. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. (*a*) Unless otherwise specified, any rejection based on chemical or physical tests made in accordance with these specifications shall be reported within five working days from the receipt of samples.

(*b*) Bars which, subsequent to their acceptance at the manufacturer's works, are shown to have contained injurious defects will be rejected, and the manufacturer shall be notified.

Rehearing. 14. Samples tested in accordance with Section 4, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
SEAMLESS COPPER BOILER TUBES.[1]

Serial Designation: B 13 – 16 T.

The specifications for this material are issued under the fixed designation B 13; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Grades. 1. These specifications cover two grades of copper tubes for locomotive boilers, namely, Arsenical and Non-Arsenical.

I. MANUFACTURE.

Process. 2. The copper shall be fire-refined or electrolytic and shall be made into tubes, either by the hot-rolling or cold-drawing process. It shall be finished by cold drawing.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The copper shall conform to the following requirements as to chemical composition:

(*a*) *Arsenical Copper.*—Arsenical copper shall contain from 0.15 to 0.35 per cent of arsenic, and shall not contain more than 0.120 per cent of impurities, exclusive of arsenic and silver.

(*b*) *Non-Arsenical Copper.*—Non-Arsenical copper shall have a purity of at least 99.880 per cent, as determined by electrolytic assay, silver being counted as copper. The total of impurities other than silver shall not exceed 0.120 per cent.

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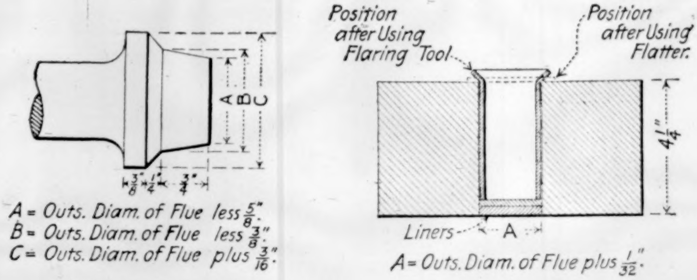
[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Chemical Analyses. 4. (*a*) Analyses of two tubes in each lot of 250 or less may be made by the purchaser, which shall conform to the requirements specified in Section 3. Drillings for analyses shall be taken from several points around each tube, or turnings may be taken from the end of the tube.

(*b*) If the analysis of any one tube does not conform to the requirements specified in Section 3, analyses of two additional tubes of the same lot shall be made, each of which shall conform to the requirements specified.

III. PHYSICAL PROPERTIES AND TESTS.

Temper. 5. Tubes will be furnished hard or annealed, as specified. Test specimens taken from hard tubes shall be annealed before testing.


A
B
C
3/8"
1/4"
3/4"
A = Outs. Diam. of Flue less 5/8".
B = Outs. Diam. of Flue less 3/8".
C = Outs. Diam. of Flue plus 3/16".
Position after Using Flaring Tool
Position after Using Flatter.
4 1/4"
Liners
A
A = Outs. Diam. of Flue plus 1/32".

Flaring Tool. Die Block.

FIG. 1.

Flange Tests. 6. (*a*) A test specimen not more than 4 in. in length shall have a flange turned over at right angles to the body of the tube, without showing cracks or flaws. This flange, as measured from the outside of the tube, shall be ⅜ in. wide for tubes 2½ in. or under in outside diameter, and ½ in. wide for tubes over 2½ in. in outside diameter.

(*b*) In making the flange test, it is recommended that the flaring tool and die block shown in Fig. 1 be used.

Crush Test. 7. A test specimen 2½ in. in length shall stand crushing longitudinally until the outside folds are in contact, without showing cracks or flaws.

Hydrostatic Test. 8. All tubes shall stand an internal hydrostatic pressure of

750 lb. per sq. in. The hydrostatic pressure test shall be applied to the finished tubes before annealing.

Test Specimens.

9. (*a*) Test specimens shall consist of sections cut from tubes selected by the inspector representing the purchaser from the lot offered for shipment. They shall be smooth on the ends and free from burrs.

(*b*) All specimens shall be tested cold.

Number of Tests.

10. One flange and one crush test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydrostatic test.

11. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS.

Standard Weights.

12. The standards weights for tubes of various outside diameters and thickness are as follows:

THICKNESS.		WEIGHT, LB. PER FT. OF LENGTH, Outside Diameter, in.				
In.	B. w. g.	1½	1¾	2	2¼	2½
0.095	13	1.624	1.913	2.202	2.491	2.779
0.109	12	1.844	2.176	2.507	2.839	3.170
0.120	11	2.015	2.380	2.744	3.109	3.474
0.134	10	2.227	2.634	3.042	3.449	3.857
0.148	9	2.434	2.884	3.334	3.785	4.235

Permissible Variations.

13. The weight of the tubes shall not vary more than 5 per cent from that specified in Section 12.

V. WORKMANSHIP AND FINISH.

Workmanship.

14. The finished tubes shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. The thickness at any point shall not vary more than 10 per cent from that specified. The length shall not be under, but may be 0.125 in. over that ordered.

Finish. 15. The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be straight, free from kinks, bends and buckles.

VI. MARKING.

Marking. 16. The name or brand of the manufacturer, and "tested at 750 lb." shall be legibly stenciled on each tube.

VII. INSPECTION AND REJECTION.

Inspection. 17. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 18. (*a*) Unless otherwise specified, any rejection based on chemical or physical tests made in accordance with these specifications shall be reported within five working days from the receipt of samples.

(*b*) Tubes when inserted in the boiler shall stand expanding and bending without showing cracks or flaws. Tubes which fail in this manner will be rejected, and the manufacturer shall be notified.

Rehearing. 19. Samples tested in accordance with Section 4, which represent rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
SEAMLESS BRASS BOILER TUBES.[1]

Serial Designation: B 14 – 16 T.

The specifications for this material are issued under the fixed designation B 14; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Scope. 1. These specifications cover brass tubes for locomotive boilers.

I. MANUFACTURE.

Process. 2. The tubes shall be cold drawn to size and semi-annealed. They shall be fully annealed at both ends, if so ordered.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The material shall conform to the following requirements as to chemical composition:

70 AND 30 ALLOY.

Copper	not under	69.00	per cent
Lead	not over	0.50	"
Iron	not over	0.10	"
Materials other than copper and zinc	not over	0.50	"
Zinc	remainder		

Chemical Analyses. 4. (*a*) Analyses of two tubes in each lot of 250 or less may be made by the purchaser, which shall conform to the requirements specified in Section 3. Drillings or turnings may be taken from the end of the tube for analyses.

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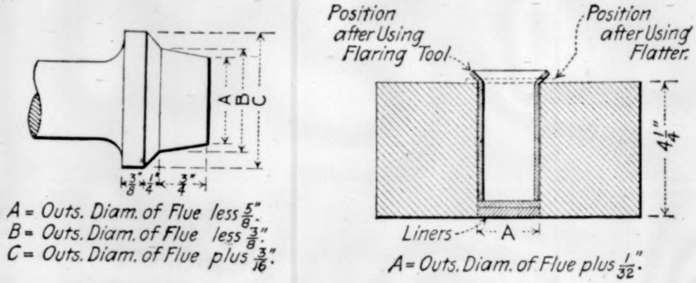
[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

(*b*) If the analysis of any one tube does not conform to the requirements specified in Section 3, analyses of two additional tubes of the same lot shall be made, each of which shall conform to the requirements specified.

III. PHYSICAL PROPERTIES AND TESTS.

Temper. 5. Test specimens taken from semi-annealed tubes shall be fully annealed before testing.

Flange Test. 6. (*a*) A test specimen not more than 4 in. in length shall have a flange turned over at right angles to the body of the tube without showing cracks or flaws. The outside diameter of this flange shall measure not less than $1\frac{1}{4}$ times the original outside diameter of the tube.


A
B
C
3/8"
1/4"
3/4"
A = Outs. Diam. of Flue less 5/8".
B = Outs. Diam. of Flue less 3/8".
C = Outs. Diam. of Flue plus 3/16".
Position after Using Flaring Tool
Position after Using Flatter.
4 1/4"
Liners
A
A = Outs. Diam. of Flue plus 1/32".

Flaring Tool. Die Block.

FIG. 1.

(*b*) In making the flange test, it is recommended that the flaring tool and die block shown in Fig. 1 be used.

Flattening and Doubling-Over Test. 7. The tubes shall be capable of standing the following test, when cold, without showing either crack or flaw: A piece of the tube shall be flattened down, until the interior surfaces of the tube meet, and then be doubled over on itself, that is, bent through an angle of 180 deg., the bend being at right angles to the direction of the length of the tube.

Hydrostatic Tests. 8. All tubes shall stand an internal hydrostatic pressure of at least 750 lb. per sq. in.

Test Specimens. 9. (*a*) Test specimens shall consist of sections cut from tubes selected by the inspector representing the purchaser from the lot offered for shipment. They shall be smooth on the ends and free from burrs.

(*b*) All specimens shall be tested cold.

Number of Tests. 10. One flange and one flattening test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydrostatic test.

11. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS.

Standard Weights. 12. The standard weights for tubes of various outside diameters and thickness are as follows:

THICKNESS.		WEIGHT, LB. PER FT. OF LENGTH, Outside Diameter, in.				
In	B. w. g.	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$
0.095	13	1.551	1.827	2.102	2.378	2.654
0.109	12	1.761	2.078	2.395	2.711	3.028
0.120	11	1.924	2.272	2.621	2.969	3.318
0.174	10	2.127	2.516	2.905	3.294	3.683
0.148	7	2.325	2.755	3.184	3.614	4.044

Permissible Variations. 13. The weight of the tubes shall not vary more than 5 per cent from that specified in Section 12.

V. WORKMANSHIP AND FINISH.

Workmanship. 14. The finished tubes shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. The thickness at any point shall not vary more than 10 per cent from that specified. The length shall not be under, but may be 0.125 in. over that ordered.

Finish. 15. The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be straight, free from kinks, bends and buckles.

VI. MARKING.

Marking. 16. The name or brand of the manufacturer, and "tested at 750 lb." shall be legibly stenciled on each tube.

VII. INSPECTION AND REJECTION.

Inspection. 17. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 18. (*a*) Unless otherwise specified, any rejection based on chemical and physical tests made in accordance with these specifications shall be reported within five working days from the receipt of samples.

(*b*) Tubes when inserted in the boiler shall stand expanding and bending without showing cracks or flaws. Tubes which fail in this manner will be rejected, and the manufacturer shall be notified.

Rehearing. 19. Samples tested in accordance with Section 4, which represent rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
BRASS FORGING ROD.[1]

Serial Designation: B 15 – 17 T.

The specifications for this material are issued under the fixed designation B 15; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These specifications cover brass rods of any specified cross-section capable of being readily forged hot, and easily machined.

I. MANUFACTURE.

Process. 2. The rods may be manufactured either by hot rolling or extrusion, and may be finished by cold drawing if necessary to meet the requirement for size.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The brass shall conform to the following requirements as to chemical composition:

Copper	58.5 – 61.5 per cent.
Lead	1.5 – 2.5 "
Iron	not over 0.15 "
Materials other than copper, lead and zinc	not over 0.35 "
Zinc	remainder.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Chemical Analyses.

4. Analyses may be made on each lot of 5000 lb. or less. Drillings or millings shall be made from at least four separate rods, equal quantities being taken from each rod and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary.

Check Analyses.

5. (*a*) Analyses of separate rods may be made by the purchaser. The copper and lead contents thus determined shall lie within the following limits:

Copper	57.9 – 62.1 per cent.
Lead	1.2 – 3.0 "

(*b*) In case of dissatisfaction, the rod or rods shall be sampled in the presence of representatives of both parties. The thoroughly mixed sample shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary.

III. PHYSICAL PROPERTIES AND TESTS.

Flattening Test.

6. Specimens cut from rods or bars and having a length equal to the diameter of the specimen, shall stand flattening in an axial direction while hot, until reduced to 20 per cent of their original length, without cracking.

Number of Tests.

7. (*a*) One flattening test shall be made from each lot of 2000 lb. or less.

(*b*) In case of failure of any test specimen representing a lot, two additional specimens shall be chosen, both of which shall conform to the requirements specified in Section 6.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Permissible Variations.

8. (*a*) The diameter of round sections, or the distance between parallel faces in the case of other sections, shall not vary from that specified more than the following:

Diameter, or Distance between Parallel Faces.	Permissible Variation, in.
Up to and including $\frac{1}{2}$ in	±0.005
$\frac{1}{2}$ to 1 in., inclusive	±0.008
1 to $2\frac{1}{2}$ in., inclusive	±0.010
Over $2\frac{1}{2}$ in	±0.015

(*b*) In the case of special shapes, the permissible variations shall be agreed upon according to the requirements.

Lengths. 9. Stock lengths for all rods from ¼ to 1 in., inclusive, in diameter or thickness shall be supplied by the manufacturer as follows:

(*a*) When ordered in 12-ft. lengths, no lengths less than 8 ft.; when ordered in 10-ft. lengths, no lengths less than 6 ft.; when ordered in 8-ft. lengths, no lengths less than 6 ft.; when ordered in 6-ft. lengths, no lengths less than 4 ft.

(*b*) When ordered in the lengths given above, the weight of lengths less than the length ordered shall not exceed 40 per cent of any one shipment.

(*c*) For rods over 1 in. up to and including 2 in. in diameter or thickness, the lengths shall be random lengths from 4 to 10 ft.; for rods over 2 in. in diameter or thickness, special lengths are required, but no length shall be less than 4 ft.

V. WORKMANSHIP AND FINISH.

Finish. 10. The rods shall be free from injurious surface defects and shall have a workmanlike finish. They shall be substantially straight.

VI. INSPECTION AND REJECTION.

Inspection. 11. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTE.

Section 1.—The material intended to be covered by these specifications exhibits a very considerable variation in properties with slight changes in composition. Its strength, stiffness and ability to stand forging operations are in inverse proportion to the copper content; so also is the amount of lead which the alloy can contain without producing hot shortness. Toughness on the other hand is directly proportional to the copper content,

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TENTATIVE SPECIFICATIONS
FOR
FREE-CUTTING BRASS ROD FOR USE IN SCREW MACHINES.[1]

Serial Designation: B 16 – 17 T.

The specifications for this material are issued under the fixed designation B 16; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These specifications cover free-cutting brass rods of any specified cross-section, suitable for high-speed screw machine work.

I. MANUFACTURE.

Process. 2. The rods shall be finished by cold drawing and straightening unless otherwise specified.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The brass shall conform to the following requirements as to chemical composition:

Copper	60.0 – 63.0	per cent.
Lead	2.25 – 3.25	"
Iron	not over 0.10	"
Materials other than copper, lead and zinc	not over 0.25	"
Zinc	remainder.	

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Chemical Analyses.

4. Analyses may be made on each lot of 5000 lb. or less. Drillings or millings shall be made from at least four separate rods, equal quantities being taken from each rod and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary.

Check Analyses.

5. (*a*) Analyses of separate rods may be made by the purchaser. The copper and lead contents thus determined shall lie within the following limits:

Copper	59.4 - 63.6 per cent.
Lead	1.8 - 3.9 "

(*b*) In case of dissatisfaction, the rod or rods shall be sampled in the presence of representatives of both parties. The thoroughly mixed sample shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary.

III. PHYSICAL PROPERTIES AND TESTS.

Bend Test.

6. Rods or bars shall bend cold through an angle of 120 deg. around a pin the diameter of which is equal to the diameter or thickness of the rod or bar without fracture.

Number of Tests.

7. (*a*) One bend test shall be made from each lot of 5000 lb. or less.

(*b*) In case of failure of any test specimen representing a lot, two additional specimens shall be chosen, both of which shall conform to the requirements specified in Section 6.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Permissible Variations.

8. The diameter of round sections, or the distance between parallel faces in the case of other sections, shall not vary from that specified more than the following:

Diameter, or Distance between Parallel Faces.	Permissible Variation, in.
Up to and including $\frac{1}{2}$ in.	±0.0015
$\frac{1}{2}$ to 1 in., inclusive	±0.002
1 to $2\frac{1}{2}$ in., inclusive	±0.0025
Over $2\frac{1}{2}$ in.	±0.003

Lengths. 9. Stock lengths for all rods from $\frac{1}{4}$ to 1 in., inclusive, in diameter or thickness shall be supplied by the manufacturer as follows:

(*a*) When ordered in 12-ft. lengths, no lengths less than 8 ft.; when ordered in 10-ft. lengths, no lengths less than 6 ft.; when ordered in 8-ft. lengths, no lengths less than 6 ft.; when ordered in 6-ft. lengths, no lengths less than 4 ft.

(*b*) When ordered in the lengths given above, the weight of lengths less than the length ordered shall not exceed 40 per cent of any one shipment.

(*c*) For rods over 1 in. up to and including 2 in. in diameter or thickness, the lengths shall be random lengths from 4 to 10 ft.; for rods over 2 in. in diameter or thickness, special lengths are required, but no length shall be less than 4 ft.

V. WORKMANSHIP AND FINISH.

Finish. 10. The rods shall be free from injurious defects, substantially straight and free from kinks and bends, and shall have a bright, smooth surface.

VI. INSPECTION AND REJECTION.

Inspection. 11. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES.

Section 1.—The material intended to be covered by these specifications is suitable for ordinary manufacturing purposes. In order to machine freely it must contain lead, and possess a considerable degree of temper which is obtained by cold working. The former requirement reduces strength and ductility while the latter adds firmness and stiffness.

Section 3.—There are four major constituents encountered in all brass alloys, the control and determination of which present very perplexing problems. They are copper, zinc, lead and iron. The high volatility of zinc, the variations in temperature which occur in the alloying operation, and the variation in the proportion in which it is added to the crucible charge in unalloyed form, causes its proportion in the casting to occasionally fluctuate over wide limits. Except when certain expensive grades of zinc are employed, substantially free from lead, the latter element will also show very considerable variation. Iron is subject to accidental introduction.

On account of the fact that the ordinary crucible charge is only about 200 lb., it is not commercially practicable to determine the four main elements in each cast. On the other hand, the determination by chemical analysis of the constituents of an individual sample from a lot of a given size tells little about the mean values of the proportions, or the extreme variations which exist in the lot. It is proposed, though not as a very satisfactory solution of this problem, to require that a sample composed of four equal portions from four individual pieces be taken to represent the mean composition of a lot, and that individual samples be permitted to vary between wider limits. It is appreciated that this is not a satisfactory solution of the problem, but no better one has been offered.

There are many uses for which alloys outside of the specified limits are perfectly suitable. The limits given, however, represent standard practice. On the other hand, there are special requirements which cannot be most advantageously satisfied by alloys meeting these specifications.

Section 6.—It is desirable that a limit be imposed on the hardness due to cold drawing. It is felt that the bend test proposed accomplishes the purpose as satisfactorily as any other test.

Section 8.—It is not commercially practicable to furnish material of this character to specific lengths without great expense, especially in the larger sizes, on account of the small size of billet employed. It is, therefore, necessary to permit considerable latitude in this respect.

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TENTATIVE SPECIFICATIONS

FOR

NON-FERROUS ALLOYS FOR RAILWAY EQUIPMENT IN INGOTS, CASTINGS, AND FINISHED CAR AND TENDER BEARINGS.[1]

Serial Designation: B 17 - 17 T.

The specifications for this material are issued under the fixed designation B 17; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Classes. 1. (*a*) These specifications cover the various non-ferrous alloys for locomotive equipment in ingots, castings and finished car and tender bearings.

(*b*) These alloys and the purposes for which they are frequently used are as follows:

Bearing Metals No. 1 and No. 2, for connection-rod bearings, bushings, eccentric straps, driving-box bearings, trailer-truck bearings, crosshead gibs, hub liners and miscellaneous bushings;

Bearing Metals No. 3 and No. 4, for lead-lined bearings, for locomotive tenders, freight and passenger car equipment;

Bell Metal, for locomotive bells only;

Babbitt Metal, for babbitting driving boxes, rod brasses, crossheads and for hub liners.

Lining Metal, for lining truck brasses, tender brasses and car brasses.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition

2. (*a*) The alloys shall conform to the following requirements as to chemical composition, with the permissible variations specified:

Alloy.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.	Iron, max., per cent.	Antimony, per cent.	Phosphorus, max., per cent.	Aluminum, per cent.	Sulfur, max., per cent.	Total Impurity, excluding Zinc, per cent.
Bearing Metal No. 1.	remainder	9–11	9–11	1.5[a]	0.4	0.5[a]	....	none	....	1.0
Bearing Metal No. 2.	remainder	7–9	14–16	1.5[a]	0.4	0.5[a]	....	none	....	1.0
Bearing Metal No. 3.	remainder	7–9	14–16	3.0[a]	0.4	0.5[a]	....	none	....	1.0
Bearing Metal No. 4.	remainder	4–6	15–20	5.0[a]	0.4	0.5[a]	....	none	....	1.0
Bell Metal..........	remainder	16–18	0.25[a]	0.25[a]	0.25	0.25[a]	0.02	none	0.05	0.5
Babbitt Metal......	0.5[a]	9–11	remainder	0.10[a]	0.05	15–17	....	none	....	0.75
Lining Metal........	0.5[a]	4–6	remainder	0.10[a]	0.05	9–11	....	none	....	0.75

[a] Maximum.

(*b*) Where no figures are given for impurity maximum, these elements may be present up to any amount to come within the total impurity specified, providing the material otherwise meets the chemical and physical tests. Where maximum percentages are specified, the elements referred to are considered as impurities and shall not be intentionally added.

Chemical Analysis.

3. An analysis will be made by the purchaser or his representative from one ingot, casting or journal bearing representing each lot. The chemical composition thus determined shall conform to the requirements specified in Section 2 for the particular alloy.

Sample for Chemical Analysis.

4. (*a*) *Ingots.*—Drillings shall be taken with a drill at least ½ in. in diameter at a point midway between the heaviest and smallest cross-section of the ingot. For ingots having two or more sections, drillings shall be taken from each section. In the case of Babbitt Metal and Lining Metal, drillings so taken shall be melted in a thoroughly cleaned ladle with a little rosin flux and poured into a piece of thin section. This piece shall be sawed into three parts and the sawings therefrom thoroughly mixed to constitute the sample for chemical analysis.

(*b*) *Locomotive Castings.*—Drillings shall be taken with a drill as large as possible at such points in the casting as shall be thoroughly representative. Drillings through the skin shall be rejected. Drillings thoroughly mixed shall constitute the sample for chemical analysis.

(*c*) *Car and Tender Bearings.*—Drillings shall be taken with a drill at least $\frac{1}{2}$ in. in diameter, at three points on the bearing selected for physical test as specified in Section 5 (*b*) as widely separated as possible. Drillings representing the skin of the casting shall be rejected. These drillings, thoroughly mixed, shall constitute the sample for chemical analysis.

Drillings shall be taken in a like manner from the lining, exercising care that the drill does not penetrate the soldered surface.

(*d*) All samples, whether taken with a drill or saw, shall be kept free of oil and shall be magnetized to remove iron introduced in taking the sample.

II. PHYSICAL INSPECTION AND TESTS.

Physical Inspection. 5. (*a*) *Locomotive Castings.*—The castings shall be sound, free from blowholes, flaws or shrinkage cracks, and shall show good foundry practice and workmanship.

One casting representing each lot of locomotive bearings will be broken by the purchaser or his representative for examination of fracture. The fracture shall disclose no shrink discoloration, segregation, dross or dirt spots within $\frac{5}{8}$ in. of the bored journal engaging surface, and shall show no distinct signs of imperfect mixture.

(*b*) *Car and Tender Bearings.*—The bearings shall be sound, free from sand, blowholes, flaws or shrinkage cracks, and shall show good foundry practice and workmanship.

One bearing representing each lot will be broken by the purchaser or his representative for examination of fracture. The fracture shall show no shrink discoloration, segregation, dross or dirt spots within $\frac{1}{2}$ in. of the bored journal engaging surface. This test shall be made before linings are applied. A second test shall be made after application of the lining as follows:

(1) The suspended brass when tapped with a hammer shall give a distinct ring.

(2) The lining when chipped with a cold chisel shall tear from the soldered surface as distinguished from clean shearing.

III. LOT.

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6. (*a*) *Ingots.*—Each 5000 lb. or fraction thereof shall constitute a lot. The ingot from which the sample is taken shall be included in the shipment.

(*b*) *Locomotive Castings* —Each 100 castings or fraction thereof unless otherwise specified shall constitute a lot.

The manufacturer shall furnish, free of cost, one casting representing each lot for purpose of tests as specified in Sections 4 (*b*) and 5 (*a*).

(*c*) *Car and Tender Bearings.*—Each 300 bearings or fraction thereof, unless otherwise specified from each pattern shall constitute a lot.

The manufacturer shall furnish, free of cost, one bearing representing each lot for purposes of tests as specified in Sections 4 (*c*) and 5 (*b*).

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

(FOR CAR AND TENDER BEARINGS ONLY.)

Permissible Variations.

7. (*a*) The purchaser will furnish drawings showing the dimensions of the bearings ordered and permissible variations therefrom and the bearings shall conform to these drawings within such permissible variations.

(*b*) The thickness at the center of the brass and of the complete bearing shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing. The thickness of the lining shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing.

V. WORKMANSHIP.

Workmanship.

8. (*a*) *Locomotive Castings.*—The castings shall conform to the dimensions specified and shall show good workmanship generally.

(*b*) *Car and Tender Bearings.*—The bearings shall show good workmanship generally, and shall be free from mechanical imperfections. They shall be bored to a true radius, and with the axis parallel to the plane of the top and perpendicular to the side lugs and bearing flange. The lettering shall be clear and distinct. No emery shall be used on journal engaging surfaces on either the brass or the lining.

VI. MARKING.

Marking. 9. (*a*) *Ingot.*—The manufacturer's marking only shall be required, unless otherwise specified.

(*b*) *Locomotive Castings.*—The lot number and other marks as required by the drawings shall be legibly marked on each casting.

(*c*) *Car and Tender Bearings.*—The name or initials of the manufacturer, the initials of the purchaser, type number, journal size, and lot number shall be legibly cast with raised figures on a depressed surface of each bearing, as shown on drawings.

VII. INSPECTION AND REJECTION.

Inspection. 10. (*a*) Inspection may be made at the manufacturer's works where the ingots, locomotive castings or car and tender bearings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry at all times while work on the contract is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Failure to meet the chemical or physical specifications, or non-conformity to any of the above requirements as to permissible variations, dimensions and markings, constitute sufficient cause for rejection of the lot represented by the sample chosen.

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TENTATIVE SPECIFICATIONS
FOR
SPELTER.[1]

Serial Designation: B 6 – 17 T.

The specifications for this material are issued under the fixed designation B 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917.

Grades. 1. Under these specifications Virgin Spelter, that is, spelter made from ore or similar raw material by a process of reduction and distillation or by electrolysis and not produced from reworked metal, is considered in five grades, as follows:

1..................High Grade.
2..................Intermediate.
3..................Brass Special.
4..................Selected.
5..................Prime Western.

Marks. 2. A brand shall be cast in each slab by which the maker and grade can be identified.

Lots. 3. The maker shall use care to have each carload of as uniform quality as possible.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Spelter (B 6–14), 1916 Book of A.S.T.M. Standards, p. 423.

Composition. 4. *1. High Grade.*[1]—The spelter shall not contain over:

0.07 per cent lead.
0.03 " iron.
0.07 " cadmium.

It shall be free from aluminum.

The sum of the lead, iron, and cadmium shall not exceed 0.10 per cent.

2. Intermediate.—The spelter shall not contain over:

0.20 per cent lead.
0.03 " iron.
0.50 " cadmium.

It shall be free from aluminum.

The sum of the lead, iron, and cadmium shall not exceed 0.50 per cent.

3. Brass Special.—The spelter shall not contain over:

0.60 per cent lead.
0.03 " iron.
0.50 " cadmium.

It shall be free from aluminum.

The sum of the lead, iron, and cadmium shall not exceed 1.0 per cent.

4. Selected.—The spelter shall not contain over:

0.80 per cent lead.
0.04 " iron.
0.75 " cadmium.

It shall be free from aluminum.

The sum of the lead, iron, and cadmium shall not exceed 1.25 per cent.

5. Prime Western.—The spelter shall not contain over:

1.60 per cent lead.
0.08 " iron.

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[1] For slush castings and certain zinc-aluminum alloys, a special grade of spelter may be required, as noted in "Spelter, Its Grades and Uses," published as Appendix I to the report of Committee B-2, *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 183 (1916).

Physical.

5. The slabs shall be reasonably free from surface corrosion or adhering foreign matter.

Sampling.[1]

6. Take ten slabs at random from a carload and saw each slab completely across from the middle of one long side to the middle of the other and use the sawdust as the sample; or, drill three 9-mm. holes along one diagonal of each slab, boring completely through and taking care to make fine drillings; the holes should be drilled as nearly as possible at the middle and halfway between either end and the middle of such diagonals. Go over the drillings or sawings with a powerful magnet to take out any iron which may have come from the drill or saw, and mix the sample thoroughly. The drill or saw shall be thoroughly cleaned before use, and no lubricant shall be used in either drilling or sawing.

Methods of Analysis.[1]

7. *Lead.*—The Electrolytic and Lead-Acid methods described below are believed to be of equal merit, so far as accuracy is concerned, but where laboratories are equipped for electrolysis the electrolytic method is preferred as a time saver.

(*a*) *Electrolytic Method.*[2]—Place 8.643 g. of the sample in a 400-cc. beaker and add sufficient water to cover the sample. Then add gradually and cautiously 30 cc. of concentrated HNO_3 (sp. gr. 1.42); when the action is complete boil the solution for a few minutes to expel nitrous fumes. Wash the watch glass and sides of the beaker and transfer the solution to a 200-cc. electrolytic beaker. Dilute to 125 cc. and electrolyze with a current of five amperes. The time required for the electrolysis is from $\frac{1}{2}$ to $\frac{3}{4}$ hour, depending upon the amount of lead present in the sample. Test the solutions for complete precipitation of lead by washing the watch glasses and sides of the beaker, so that the depth of the solution is increased about 12 mm. Then continue the current for 15 minutes and if the newly exposed surface is still bright, the lead is completely deposited. Wash the anode three or four times with distilled water, once with alcohol and then dry in an oven, or on a hot plate, at 210° C. for ½ hour and weigh.

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[1] Section 6 on Sampling and Section 7 on Analysis are based on the Report of the Sub-Committee on Methods of Analysis of Non-Ferrous Alloys of the Division of Industrial Chemists and Chemical Engineers of the American Chemical Society, approved by the Supervisory Committee on Standard Methods of Analysis of that Society; *Journal of Industrial and Engineering Chemistry*, Vol. 7, 1915, p. 547.

[2] The empirical factor weight (8.643) is used instead of the theoretical one (8.66), as the dried dioxide is liable to contain some adherent and included water, expelled with difficulty. E. F. Smith's "Electro-Analysis," 4th edition, p. 102.

The weight of the PbO_2 in milligrams, divided by 100, will give the percentage of lead. The PbO_2 deposit can be readily removed by covering the anode with dilute HNO_3 and inserting a rod of copper.

The electrodes are cylinders of platinum gauze with 400 meshes per sq. cm. The anodes are 30 mm. in diameter, by 30 mm. high, with a stem 105 mm. long of No. 16 B. & S. gage wire (1.29 mm.), making the total height 137 mm. The cathodes are 12 mm. in diameter by 30 mm. high, with a stem 105 mm. long of No. 16 B. & S. gage wire, making the total height 137 mm.

(*b*) *Lead-Acid Method.*[1]—Place in a 350-cc. beaker 25, 15, 10 or 5 g. of the drillings or sawings, according to whether the spelter is of Grade 1, 2, 3, 4 or 5, respectively, and add, according to the size of the sample taken, 300, 180, 120 or 60 cc. of lead acid. After all but about 1 g. of the spelter is dissolved, filter on a close filter and wash out the beaker a couple of times with lead acid from a wash bottle. Wash the undissolved matter from the filter into the original beaker with water and dissolve with a small amount of hot 1 : 1 HNO_3. Add 40 cc. of lead acid, and evaporate until strong fumes of H_2SO_4 escape. When cool, add 35 cc. of water (which is the quantity of water evaporated from the lead acid) and heat to boiling. Add the first filtrate (containing the greater part of the zinc, and possibly a small amount of $PbSO_4$), stir well, and allow to stand for at least five hours, preferably over night. Filter on a Gooch crucible, wash with lead acid, then with a mixture of equal parts of alcohol and water, and finally with alcohol alone. Set the Gooch crucible inside a porcelain crucible in order to avoid reduction of lead by flame gases and mechanical disintegration of the asbestos mat. Ignite for five minutes at the full heat of a Tirrell burner. Cool and weigh as $PbSO_4$.

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[1] "Lead Acid" is a solution of one volume of H_2SO_4 in seven volumes of water, saturated with $PbSO_4$. It is prepared as follows: 300 cc. of H_2SO_4 (sp. gr. 1.84) are poured into 1800 cc. of water; 1 g. of lead acetate is dissolved in 300 cc. of water and is added to the hot solution with stirring. The solution is allowed to settle for several days and is siphoned off through a thick asbestos filter for use. When "lead acid" is used it is unnecessary to consider the solubility of the $PbSO_4$, since the solution is always brought back to the same volume as the volume of "lead acid" originally added; consequently, when the $PbSO_4$ is filtered no more lead remains in the filtrate than was originally added in the "lead acid."

Iron.—Place 25 g. of spelter in a tall 700-cc. beaker and dissolve cautiously in 125 cc. of HNO_3 (sp. gr. 1.42). Boil, dilute to about 300 cc., add 10 g. of NH_4Cl, and then ammonia until the precipitated $Zn(OH)_2$ has redissolved. Boil, let settle and filter on an 11-cm. S. & S. "Black Ribbon" or similar filter paper. Wash with dilute ammonia and with hot water. Dissolve the precipitated $Fe_2(OH)_6$ with hot 1 : 4 H_2SO_4, add 40 cc. of 1 : 1 H_2SO_4, pass through a Jones reductor,[1] wash first with 150 cc. of dilute H_2SO_4 and then with 100 cc. of water and titrate with $KMnO_4$. The $KMnO_4$ solution contains approximately 0.2 g. of the crystals per liter. One cubic centimeter of $KMnO_4$ solution will equal about 0.000334 g. of iron. Run a blank with the same amounts of acid and water and correct accordingly.

Standardize the $KMnO_4$ against sodium oxalate. Weigh duplicate samples of sodium oxalate, 0.0200 g. each, an amount which may require between 49 and 50 cc. of the $KMnO_4$ solution. To convert sodium oxalate to iron, use the factor 0.833.

Cadmium.—Place 25 g. of drillings in a tall 500-cc. beaker; add 250 cc. of water and 55 cc. of concentrated HCl and stir. When the action has almost ceased add more acid with stirring, using about 2 cc. at a time, and allowing to stand after each addition of acid, until finally all but about 2 g. of the zinc have been dissolved.[2] About 60 cc. of acid in all are usually required; it is best to allow the first 55 cc. of acid to act over night. Filter, first transferring one of the undissolved pieces of zinc to the filter, and wash a couple of times with water. Discard the filtrate. Wash the undissolved matter on the filter paper into the 500-cc. beaker, cover, and dissolve in HNO_3. Transfer to a casserole, add 20 cc. of 1 : 1 H_2SO_4 and evaporate until fumes appear, take up with about 100 cc. of water, boil, cool, and let settle for several hours (best over night). Filter off the $PbSO_4$ on paper, wash with water, retain the filtrate and discard the $PbSO_4$. Dilute the filtrate to 400 cc., add about 10 g. of NH_4Cl, and pass H_2S for one hour. It is occasionally necessary to start the precipitation of the CdS by the addition of a drop or two of ammonia to the dilute solution. Allow to stand until the precipitate has settled, and then filter off the impure CdS in a loose-bottom Gooch crucible; remove the CdS by carefully punching out the bottom into a tall 200-cc. beaker. Wipe off any CdS remaining on the sides of the crucible, using a little asbestos pulp, add 60 cc. of 1 : 5 H_2SO_4 and boil for one-half hour. In case of spelters carrying large amounts of cadmium it may be necessary to add more acid. The dilute acid dissolves cadmium and zinc sulfides, but not lead sulfide. Filter and dilute to 300 cc., add about 5 g. of NH_4Cl and precipitate with H_2S again in order to get rid of traces of zinc. In case a large amount of cadmium is present, a third precipitation may be necessary. After the final precipitation, let settle, filter and transfer to a weighed platinum dish, cover, and dissolve in 1 : 3 HCl. Also dissolve the sulfide remaining on the filter paper in hot 1 : 3 HCl, and add it to the solution in the platinum dish. Add a little H_2SO_4 and evaporate the solution until copious fumes escape. Dilute with water, add a few cubic centimeters of concentrated HNO_3 to oxidize any filter-paper shreds, and again evaporate the solution until fumes of H_2SO_4 come off freely. Remove the excess of H_2SO_4 by heating the dish cautiously, and finally heat to between 500 and 600° C. or to dull redness, and weigh the cadmium as sulfate.

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[1] If, before passing the solution through the reductor, a large amount of $PbSO_4$ is present, it is well to filter it off so as to prevent it from clogging the reductor.

[2] Care should be taken that the solution of the sample proceeds slowly, particularly towards the last, and that the stated amount of spelter remain in the undissolved residue.

Alternate Method for Cadmium.—Proceed as above until the CdS has been dissolved in HCl. Oxidize with HNO_3 and filter from sulfur. Transfer the solution to a 200-cc. electrolytic beaker, add a drop or two of phenolphthalein and then pure NaOH or KOH solution until a permanent red color is obtained. Add a strong solution of pure KCN with constant stirring until the precipitate of $Cd(OH)_2$ is completely dissolved. Avoid using an excess of the KCN. Dilute the solution to 150 cc. and electrolyze with a current of five amperes, using gauze electrodes of the same size as in the lead determination. The time required is 1 to 2 hours. The solution should always be tested for cadmium as follows: Raise the liquid in the beaker and then note after twenty minutes the newly exposed surface of the electrode. If it is still bright, the cadmium is completely deposited. Next wash the electrodes with distilled water and then with alcohol. Dry at 100° C., cool and weigh. The increase is metallic cadmium.

Claims.

8. Claims to be considered shall be in writing within thirty days of receipt of material at customer's plant and the results of customer's test shall be given. The shipper shall be given one week from date of receipt of such claim to investigate his records and then shall either agree to satisfy the claim or send a representative to the plant.

(*a*) *Analysis by Car Lots.*—No claims shall be considered unless the minimum samples as specified for the grade in question can be shown to such representative.

(*b*) *Physical Defects of Individual Pieces.*—No claims shall be considered unless the spelter in question, unused, can be shown to such representative.

Plant Treatment.

9. Where the spelter satisfies the chemical and physical requirements of these specifications, it shall not be condemned for defects of alloys in which it is used or for defects in the coating of galvanized products.

Investigation of Claims.

10. The maker's representative shall inspect all pieces where physical defects are claimed. If agreement is not reached the question of fact shall be submitted to a mutually agreeable umpire, whose decision shall be final.

On a question of metal contents a sample shall be drawn by representatives of both parties as described under "Sampling," Section 6. The properly mixed and quartered sample shall be separated into three parts, each of which shall be placed in a sealed package, one for each party and one for an umpire if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality, and whose determination shall be final.

Settlement of Claims.

11. The expenses of the seller's representative and of the umpire shall be paid by the loser or divided in proportion to concession made in case of compromise.

In case of rejection being established, damages shall be limited to the payment of freight both ways by the seller for substitution of an equivalent weight of spelter meeting these specifications.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS FOR ANALYSIS OF ALLOYS OF LEAD, TIN, ANTIMONY AND COPPER.[1]

Serial Designation: B 18 – 17 T.

These methods are issued under the fixed designation B 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. GENERAL METHOD.[2]

1. Dissolve 1 g. of the finely divided alloy by boiling in from 70 to 100 cc. of the following solution in a covered beaker: The solution is made by dissolving 20 g. of KCl in 500 cc. of water, then adding 400 cc. of concentrated HCl, mixing, and then 100 cc. of HNO_3 (sp. gr. 1.40). No decomposition between HCl and HNO_3 takes place in this solution in the cold. If complete solution of the alloy is difficult in the amount of the solution taken, more is added as required. Continue boiling until solution is evaporated to about 50 cc.

Lead. (*a*) Add 5 cc. of concentrated HCl and cool by placing beaker in ice water until the bulk of the lead has crystallized out as chloride. Then add slowly 50 cc. of 95-per-cent alcohol from a pipette, with constant stirring; stir for a few minutes longer after the alcohol has been added and place the beaker in ice water for ten minutes. Add 50 cc. more alcohol in the same way, allow to stand in ice water for 20 minutes and filter through 9-cm. paper into an 800-cc. beaker. Wash by decantation three times with a mixture of 95-per-cent alcohol and concentrated HCl (4 : 1) and wash paper twice with same mixture. With proper manipulation this treatment should uniformly precipitate all but 0.003 g. of lead. The most favorable conditions are obtained by allowing to stand, cold, over night before adding the alcohol.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

[2] G. W. Thompson's method. See *Journal*, Soc. Chem. Ind., Vol. 15, p. 179.

Wash the lead chloride on paper back into beaker and wash paper several times with hot water, allowing washings to flow into beaker with the rest of the chloride. Finally, wash twice with a solution of hot ammonium acetate (the ammonium-acetate solution is made by taking one volume of ammonia water 0.900 sp. gr., adding to it one volume of water, and then 80-per-cent acetic acid until it is slightly acid to litmus) and heat until lead chloride is all dissolved. The solution should remain perfectly clear, turbidity indicating the presence of tin or antimony; even 1 mg. of tin or antimony will cause a slight but distinct turbidity. Add 15 cc. of saturated solution of $K_2Cr_2O_7$, heat until precipitate is of good orange color, filter on weighed Gooch crucible, wash with water, alcohol and ether, dry at 110° C., and weigh. Calculate to lead by the empirical factor 63.75.

Evaporate the filtrate from lead chloride by boiling on hot plate in the loosely covered 800-cc. beaker, and finally to dryness on water bath, with cover removed. Add 10 cc. of the solution of KOH (1 g. to 5 cc.) and after a few minutes 20 cc. of 3-per-cent H_2O_2. Test the solution by dropping into it a small piece of litmus paper, and, if acid, add more KOH, little by little, until it shows an alkaline reaction. Heat on water bath for 20 minutes, add 10 g. of ammonium oxalate, 10 g. of oxalic acid, and 200 cc. of water. Heat to boiling, pass H_2S with solution near boiling for 45 minutes, filter at once, and wash precipitate with hot water.

(*b*) Concentrate, if necessary, or if the tin in the portion of **Tin.**

the sample taken for analysis amounts to 0.5 g. or over, add 5 g. more oxalic acid, and electrolyze over night, using cylindrical cathodes 2 by $1\frac{3}{8}$ in. diameter, of platinum wire gauze, with a current of about $\frac{1}{2}$ ampere. Usually by morning the solution will have become alkaline, in which case it may be taken for granted that the tin is all precipitated on the cathode. The best results are obtained, however, by regulating the current density so as to render the solution alkaline only a very short time before the cathode is to be removed; and it is desirable as a precaution to add 5 g. of oxalic acid after the solution has become alkaline, boil and re-electrolyze. Remove the cylinder, wash twice with water, and then with 95-per-cent alcohol, dry in oven, and weigh. Wash the precipitate of antimony and copper sulfides on the filter paper back into the beaker with the least amount of water possible and treat with 10 cc. of KOH solution (1 : 5), heat on a water bath until the undissolved matter is distinctly black, then filter through same paper it was washed from into a 12-oz. Erlenmeyer flask, wash, etc.

Copper. (*c*) On filter the copper is obtained as sulfide with a small amount of lead which failed to be precipitated as chloride. (If it is desired to determine this lead, it can be done by separation from the copper as usual.) Dry and ignite precipitate in small casserole, dissolve in HNO_3, boil to expel nitrous fumes, neutralize with Na_2CO_3, add a few drops of ammonia, and determine volumetrically with KCN standardized against pure copper. If the amount of copper present is from 8 to 10 mg. or more, it is determined electrolytically in HNO_3 solution, and the small amount of lead may be obtained and weighed on the anode as dioxide.

If only small amounts (less than 10 mg.) of antimony and copper are present in the sample, the lead, which failed to be precipitated as chloride, may also fail to come down as sulfide on passing H_2S through the oxalic-acid solution. It will remain in the filtrate from the sulfides and will be deposited electrolytically with the tin on the cathode. This can be prevented by adding an oxalic-acid solution of a pure antimony salt equivalent to about 100 mg. of antimony just before passing H_2S. In this case antimony, if present in the sample, must be determined on a separate portion.

(*d*) The solution of antimony sulfide in KOH should not amount to over 40 cc.; add 50 cc. of concentrated HCl and boil for some time in order to expel arsenic as arsenious chloride. Now add 25 cc. more of concentrated HCl and 1 g. $KClO_3$, boil until solution is colorless and free chlorine is driven off, filter into similar flask through mineral wool if sulfur has separated, wash out original flask with concentrated HCl, cool, add 1 g. of KI, 1 cc. of CS_2, and titrate for antimony with N/10 sodium-thiosulfate solution, 1 cc. of which equals 0.0060 g. of antimony. **Antimony.**

This systematic method assumes the absence of other metals than lead, tin, antimony, and copper.

2. *Determination of Arsenic.*—Arsenic is determined on a separate portion as follows: Weigh out 1 g. of the finely divided sample and transfer to a distillation flask, together with 10 cc. of ferric-chloride solution (sp. gr. 1.43) free from arsenic; 60 cc. of concentrated HCl; 20 cc. of water; 5 g. of KCl. Connect the flask with a condenser, heat slowly until solution is complete, and distill, boiling to as small a volume as possible. When cool add 50 cc. more concentrated HCl and redistill. Pass H_2S through the cold distillate for an hour, allow to settle, filter and weigh the arsenious sulfide on a Gooch crucible, washing with HCl, cold water, alcohol and CS_2. After drying and weighing, redissolve with ammonium-carbonate solution, wash thoroughly with water and reweigh the Gooch crucible, calculating the loss in weight to arsenic. **Arsenic.**

II. RAPID VOLUMETRIC METHODS FOR FACTORY CONTROL WORK.

DETERMINATION OF LEAD.

(MOLYBDATE METHOD.)

3. Treat 1 g. of the finely divided alloy in a covered beaker with 2 to 5 g. of tartaric acid and 10 cc. of water. Add slowly with constant stirring 10 cc. of HNO_3 (1 : 1) and heat gently—not above 60° C.—until the bulk of the sample is dissolved. Complete the solution (of antimony and copper) by heating on steam bath, and, if necessary, adding two or three drops of HNO_3 (concentrated). This treatment should give a clear solution, with formation of no metastannic acid. Add slowly **Lead.**

10 cc. of H_2SO_4 (1 : 1) with constant stirring and then evaporate until nitrous fumes are no longer given off; but the evaporation should be stopped before the tartaric acid begins to char. Cool, dilute and filter off lead sulfate, washing with dilute H_2SO_4 (1 : 10).[1] Place the precipitate and filter in a flask, add 10 cc. of strong HCl and boil until the filter is well disintegrated, then add 15 cc. of strong HCl, 25 cc. of cold water and 25 cc. of strong ammonia water. Now color with a little litmus solution, make slightly alkaline with ammonia if not already so, and then make distinctly acid with strong acetic acid. Heat to boiling and see that the lead sulfate is entirely dissolved, then dilute to about 200 cc. with boiling-hot water and titrate with standard ammonium molybdate solution as follows: Pour about two-thirds of the hot lead solution into a large beaker and run the molybdate solution into it from a burette until a drop from the beaker, when placed on a glazed porcelain plate and touched with a drop of a solution of tannic acid (about 0.1 g. dissolved in 20 cc. of water), gives a brown or yellow tinge. Now add more of the lead solution from the flask and continue the titration until the end-point is again passed. Continue thus to approach the true end-point, using more caution each time. Finally, when only a few cubic centimeters remain in the flask, pour the entire mixture in the beaker into the flask and then back into the beaker again and finish the titration two drops at a time. When the final yellow tinge is obtained, some of the immediately preceding tests may have developed a tinge also. From the reading of the burette deduct the volume of two drops for each test thus showing a color. Multiply the corrected reading by the percentage value of 1 cc. of the molybdate solution in lead to obtain the percentage of lead in the sample.[2]

The ammonium-molybdate solution is made by dissolving about 4.74 g. of ammonium molybdate in water and making up to one liter. It is standardized by treating about 0.2 g. of pure lead foil in exactly the same way as described for the treatment of the sample. This method is not accurate for alloys containing less than 2 per cent of lead.

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[1] See "The Analysis of Non-Ferrous Alloys," Ibbotson and Aitchison, p. 192, Method II, and "Technical Analysis of Brass," Price and Meade, p. 156.

[2] "Technical Methods of Ore Analysis," A. H. Low, pp. 129 and 131.

DETERMINATION OF TIN.

(PEARCE-LOW IODINE METHOD.)

Tin.

4. Weigh 0.2 to 1.0 g. (depending on the percentage of tin) of the finely divided alloy into a 12-oz. wide-mouth conical flask. Add 20 cc. of concentrated HCl and when most of the soluble metal is dissolved add $KClO_3$, a little at a time, until solution is complete. Boil off all the chlorine and then add 50 to 75 cc. of concentrated HCl, depending on the amount of antimony present. Make the solution up to a volume of 200 cc. with water. Prepare a nickel coil by rolling 6 sq. in. of heavy sheet nickel ($1\frac{1}{2}$ by 4 in.) into a loose roll of such a size that it may be easily inserted into the flask. Leave a narrow strip of nickel attached to one side of the coil and long enough to reach above the top of the flask when the coil is on the bottom. Place the coil in the solution in the flask, bend the nickel strip over the edge and cover with a small watch glass. Heat to boiling and maintain gentle ebullition for 30 minutes after all the iron which may be in the solution is reduced, which may be told by the yellow color of the solution changing to a pale green. Remove the flask from the hot plate and at once, while the solution is still hot and hydrogen still being evolved, place the rubber stopper carrying the tube from a CO_2 generator in the neck of the flask. Start the current of CO_2 and place the flask in the cooling trough.

When the solution in the flask has cooled to room temperature remove the stopper and drop in two $\frac{1}{2}$-in. cubes of crystallin marble. Remove the nickel coil, washing it with cold HCl solution (1 strong acid : 3 water), as it is withdrawn from the flask. This washing solution must be boiled to expel any free chlorine and then cooled before using. Add a little starch solution and titrate at once with standard iodine solution until the characteristic blue color indicates the end point.

The standard iodine solution most convenient for this titration is prepared by dissolving 10.7 g. of iodine in 50 cc. of water containing 20 g. of KI in solution, and making up to one liter with water. This can be standardized with pure tin or with a solution of sodium thiosulfate of exactly known value.[1]

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[1] See "The Volumetric Determination of Tin," R. L. Hallett, *Journal*, Soc. Chem. Ind., Vol. XXXV, No. 21.

DETERMINATION OF ANTIMONY.

(LOW'S PERMANGANATE METHOD.)

Antimony. 5. Treat 1 g. of the finely divided alloy in a 300-cc. Kjeldahl flask with 10 to 15 cc. of concentrated H_2SO_4 and heat over a Bunsen flame until the alloy is thoroughly decomposed and all separated sulfur has been driven off. Do not drive off all free H_2SO_4, but have from 7 to 10 cc. left to keep the melt from getting hard on cooling. Cool, add 20 cc. of water and 20 cc. of concentrated HCl and boil to make sure that all SO_2 is driven off. If arsenic is present in the alloy in only small amounts as an impurity it will be volatilized here and not interfere with the determination of antimony. However, the solution should in no case reach a temperature of 120° C. or over after the addition of HCl or there is danger of volatilizing antimony chloride. Cool and add water to a total volume of 200 cc., adjusting the strength of HCl to 1 : 10 for small amounts of antimony, or 1 : 5 for larger amounts. Titrate the cold solution rapidly with $KMnO_4$ solution, which has been standardized against pure metallic antimony treated exactly as described above for determination of the alloy. The true end point is reached when the whole solution is colored pink by one drop after agitation. The end point is sharp but the color may soon disappear, owing to the amount of HCl present.[1]

DETERMINATION OF COPPER.

Copper. 6. Dissolve 1 g. of the fine sawings in a No. 3 beaker in 45 cc. of strong HCl and 5 cc. of strong HNO_3. Boil down to about 15 or 20 cc. to expel free chlorine. Remove from the plate and wash down the sides of the beaker and cover glass with a fine jet of HCl (sp. gr. 1.10) from a wash bottle using as little as possible. Dilute with water to about 75 cc. and add 5 g. of tartaric acid dissolved in 15 or 20 cc. of water. Make alkaline with ammonia till a clear blue solution is obtained and then add strong HCl drop by drop till the blue changes to light green and a slightly acid solution is obtained. If any lead chloride remains undissolved, heat on the plate a little below boiling till it is in solution. The solution should now be clear and hot. Add 2 cc. of stannous-chloride solution (225 g. to 1000 cc. of 1.10 HCl). Follow at once with 0.5 g. of potassium sulfocyanate dissolved in a little water. The copper precipitates completely as CuSCN and in a perfectly pure condition, barring a fractional part of a milligram of lead that seems to be carried down. Warm on the hot plate for a few minutes and filter through a single paper containing a little paper pulp. Wash thoroughly with hot water.[1]

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[1] See "Determination of Antimony and Tin," W. H. Low, *Journal*, Am. Chem. Soc., Vol. XXIX, p. 66; and "Rapid Analysis of Babbitt Metal," Percy H. Walker and H. A. Whitman, *Journal of Industrial and Engineering Chemistry*, Vol. I, p. 519.

Dry and ignite the precipitate in a small porcelain casserole or crucible, dissolve in a small amount of HNO_3, and boil to expel nitrous fumes. If the copper in the sample amounts to less than 8 to 10 mg., determine volumetrically with KCN as described under "General Method." If the amount of copper present is from 8 to 10 mg. or more, determine volumetrically as cuprous iodide, as follows:

Transfer the HNO_3 solution of copper to a flask of 250 cc. capacity, add 5 cc. of strong bromine water and boil until all nitrous fumes and bromine are expelled. Add a slight excess of ammonia and boil the excess off, then add strong acetic acid in slight excess, cool, add 3 g. of KI and titrate at once with N/10 sodium-thiosulfate solution until the free iodine is nearly removed, then add some starch liquor and continue the titration cautiously until the color due to free iodine has entirely vanished.[2]

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[1] Method of separation used by R. S. MacPherran, Chief Chemist, Allis-Chalmers Manufacturing Co.

[2] "Technical Methods of Ore Analysis," A. H. Low, p. 79.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS AND TESTS FOR COMPRESSIVE STRENGTH OF PORTLAND-CEMENT MORTARS.[1]

Serial Designation: C 9 – 16 T.

These specifications and tests are issued under the fixed designation C 9; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

SPECIFICATIONS.

Compressive Strength.

1. The average compressive strength in pounds per square inch of not less than three standard mortar test pieces (see Section 4) composed of one part cement and three parts standard sand, by weight, shall be equal to or higher than the following:

Age at Test, days.	Storage of Test Pieces.	Compressive Strength, lb. per sq. in.
7	1 day in moist air, 6 days in water	1200
28	1 day in moist air, 27 days in water	2000

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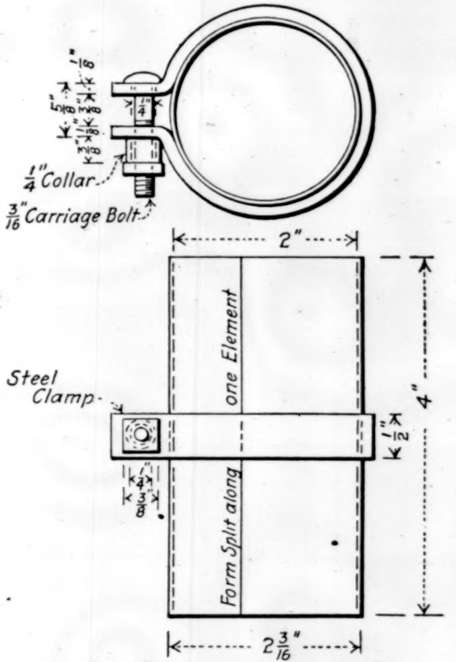
[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed, preferably before January 1, 1918, to Mr. P. H. Bates, Secretary of Committee C-1 on Cement, Bureau of Standards, Pittsburgh, Pa.

These specifications and tests, when adopted as standard, will be added to the present Standard Specifications and Tests for Portland Cement (C 9–17), 1916 Book of A.S.T.M. Standards, p. 429.

2. The average compressive strength of standard mortar at 28 days shall be higher than the strength at 7 days. **Strength at 28 Days.**

TESTS.

3. The requirements governing the preparation of standard sand mortars for tension test pieces shall apply to compression test pieces.[1] **Mixing Standard Mortar.**


1/16"
5/8"
3/8"
1/4"
1/16"
3/8"
1/4" Collar
3/16" Carriage Bolt
2"
Steel Clamp
one Element
Form Split along
4"
1/2"
1/4"
3/8"
2 3/16"

Note: Form may be Made of Seamless Brass Tubing of 2¼" Outside Diameter, No. 12 B. W. G., with ⅛" Slot along one Element.

FIG. 1.—Details for 2 by 4-in. Cylinder Form.

4. A cylindrical test piece 2 in. in diameter and 4 in. in length is recommended for use in making compression tests of standards mortars. The molds shall be made of non-corroding metal. A satisfactory form of mold is shown in Fig. 1. The ends of the mold shall be parallel. The tubing used in the **Form of Test Piece.**

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[1] See Standard Specifications and Tests for Portland Cement (C 9-17), 1916 Book of A.S.T.M. Standards, p. 429.

molds shall be of sufficient thickness to prevent appreciable distortion. The molds shall be oiled before using. During the molding of the test piece, the mold shall rest on a clean, plane surface (preferably a piece of plate glass which is allowed to remain in place until the mold is removed).

Molding. 5. The mortar[1] shall be placed in the mold in layers about 1 in. in thickness, each layer being tamped by means of the steel tamper shown in Fig. 2. The weight of tamper shall be approximately $\frac{3}{4}$ lb. In finishing the test piece, the mortar shall be heaped above the mold and smoothed off with a trowel. As soon as the test pieces from one sample are molded, the top of each test piece shall be covered with a piece of glass which is brought to a firm bearing on the fresh mortar. The cover glasses shall remain in place until the molds are removed.

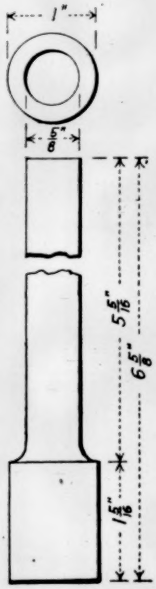

FIG. 2.—Details for Steel Tamper.

Storage. 6. The compression test pieces shall be stored in the same manner as the tension test pieces.

Testing. 7. Tests of standard-mortar cylinders shall be made in any testing machine which is adapted to meet the specified requirements. The test pieces shall be tested as soon as removed from the water. The ends of the test cylinders shall be smooth, plane surfaces. The metal bearing plates of the testing machine shall be placed in direct contact with the ends of the test piece. During the test a spherical bearing block shall be used on top of the cylinder. In order to secure a uniform distribution of the load over the test cylinder the spherical bearing block must be accurately centered. The diameter of the spherical bearing block should be only a little greater than that of the test piece. The test piece shall be loaded continuously to failure. The moving head of the testing machine shall travel at the rate of not less than 0.05 or more than 0.10 in. per minute.

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[1] If sufficient mortar for six 2 by 4-in. cylinders is to be mixed in a single batch, approximately 3000 g. of material will be required. In this case the mixing shall be continued for $1\frac{1}{2}$ minutes.

Calibration.

8. Testing machines should be frequently calibrated in order to determine their accuracy.

Faulty Cylinders.

9. Cylinders that are manifestly faulty, or which give strengths differing more than 15 per cent from the average value of all test pieces tested at the same period and made from the same sample, shall not be considered in determining the compressive strength.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
CLAY SEWER PIPE.[1]

Serial Designation: C 13 - 17 T.

The specifications for this material are issued under the fixed designation C 13; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These specifications cover clay products intended to be used for the conveyance of sewage, industrial wastes and storm water.

Single Class. 2. Sewer pipes furnished under these specifications shall be of a single class to be designated "A.S.T.M. Clay Sewer Pipe."

I. MATERIAL AND MANUFACTURE.

Materials. 3. (*a*) Clay pipes shall be manufactured from clay, fire clay or shale, or a combination of these materials.

(*b*) *Clay.*—Clay is intended to mean red burning plastic clay devoid of fissile fracture with maturing temperature about 1170° C. (2138° F.).

(*c*) *Fire Clay.*—Fire clay is intended to mean buff, gray or reddish burning fire clay showing conchoidal structure, with maturing temperature about 1250° C. (2282° F.).

(*d*) *Shale.*—Shale is intended to mean red burning hard clay with a distinct fissile fracture and vitrifying at from 1050 to 1250° C. (1922 to 2280° F.).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipes, 170 Broadway, New York City.

(*e*) The materials shall possess such physical and chemical properties that when molded into pipes and subjected to a suitable temperature the product will be strong, durable and serviceable, free from objectionable defects, and in compliance with these specifications and tests.

II. CHEMICAL TESTS AND REQUIREMENTS.

Chemical Tests and Requirements.

4. The consumer or purchaser may prescribe in advance special chemical requirements in cases where industrial wastes have marked acid or alkaline character, or are of abnormally high temperatures. He may make use of chemical analysis of the pipe material to ascertain whether these special requirements are met. The presence of visible grains or masses of caustic lime, iron pyrites or any other materials which cause slaking or disintegration shall be a cause for rejection.

III. PHYSICAL TESTS.

Physical Tests.

5. The physical tests of pipes shall include: crushing test, hydrostatic pressure test, and absorption test.[1]

Test Specimens.

6. The specimens to be tested shall be selected by the purchaser or his representative at the point or points designated by him when placing the order. The manufacturer or seller shall furnish specimens for test, without separate charge, up to 1 per cent of the number of pipes to be delivered or furnished in each size of pipe. The minimum number of specimens for any delivery less than 200 pieces shall be two specimens in each size of pipe.

Acceptance or Rejection on Result of Tests.

7. Failure of 20 per cent of the specimens to meet the requirements of any of the tests imposed, shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 per cent of the specimens in any size failing to meet the requirements, the manufacturer or seller may, with the consent of the consumer or purchaser, furnish for test additional specimens from the same shipment without charge. In case more than 80 per cent of the specimens tested, including those first tested, shall show substantial compliance for each of the various tests

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[1] Committee C-4 will prepare a specification also for an abrasion test.

TABLE I.—DIMENSIONS, ETC., OF CLAY SEWER PIPE FURNISHED AS TEST SPECIMENS.

Specimen No.	Date.	Job No.	Material.	Manufacturer.	Location of Factory.	Nominal Size, in.	Weight, lb.	Length, ft.	Thickness of Spigot, in.				Thickness of Hub, in.				Internal Diameter, in						Remarks.
																	Spigot.		Back of Hub.		Hub.		
									Invert.	Crown.	Side.	Side.	Invert.	Crown.	Side.	Side.	Vertical.	Hori-zontal.	Vertical.	Hori-zontal.	Vertical.	Hori-zontal.	

performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected.

Measurement and Observation of Specimens.

8. The specimens of pipes shall be sound, full-size pipe. They shall first be freed from all visible moisture. When dry each specimen shall be weighed, measured and inspected. The results of these observations shall be recorded and preserved as shown in Table I.

Rejection of Defective Specimens.

9. Specimens which, when placed in a vertical position, do not give a metallic ring when struck with a hammer, or are observed to have fire cracks or other defects in form or dimensions in excess of the limits permitted in these specifications, shall be discarded and replaced with additional specimens from the shipment.

(*A*) *Crushing Tests.*

Application of Load.

10. (*a*) Any prime mover or hand power which will apply the load at a uniform rate of about 2000 lb. per minute, or in increments of not more than 100 lb. at the same rate, may be used in making the test.

(*b*) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(*c*) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part.

(*d*) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(*e*) The load shall be applied until the pipe yields by cracks passing through the shell.

Knife or Two-Edge Bearings.

11. (See Fig. 1, Plate I.).—Except as otherwise hereinafter specified, the pipe to be tested shall be supported by a metallic knife bearing 1 in. wide and extended from a point just back of the hub to the spigot end of the pipe. Before the pipe is placed a fillet of plaster of Paris and sand 1 in. wide, and thick enough to compensate for all the inequalities of the pipe barrel, shall be cast on the surface of the knife-edge bearing. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The load shall be applied through an upper knife bearing of the same size and length as the lower bearing.

A plaster-of-Paris filet 1 in. wide shall be cast along the length of the crown of the pipe to equalize the lower bearing before the upper one is brought into contact.

Both of the bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the tests without lost motion, vibration or sudden shock.

At the option of the consumer or purchaser the crushing test may be applied with sand bearings or with two or three-edge bearings.

The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the hub to the end of the spigot; and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00

Three-Edge Bearings.

12. (See Fig. 2, Plate I.).—When three-edge bearings are used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test.

The two lower bearings shall consist of two wooden strips with vertical sides, each strip having its interior top corner rounded to a radius of approximately $\frac{1}{2}$ in. They shall be straight, and shall be securely fastened to a rigid block with their interior vertical sides 1 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied through the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings.

In testing a pipe which is "out of straight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair bearings.

Sand Bearings.

13. (See Fig. 3, Plate I.).—When sand bearings are used, the ends of each specimen of pipe shall be accurately marked prior to the test in quarters of the circumference. Specimens

PLATE I.
PROC. AM. SOC. TEST. MATS.
VOLUME XVII, PART I.

TENTATIVE SPECIFICATIONS FOR SEWER PIPE.

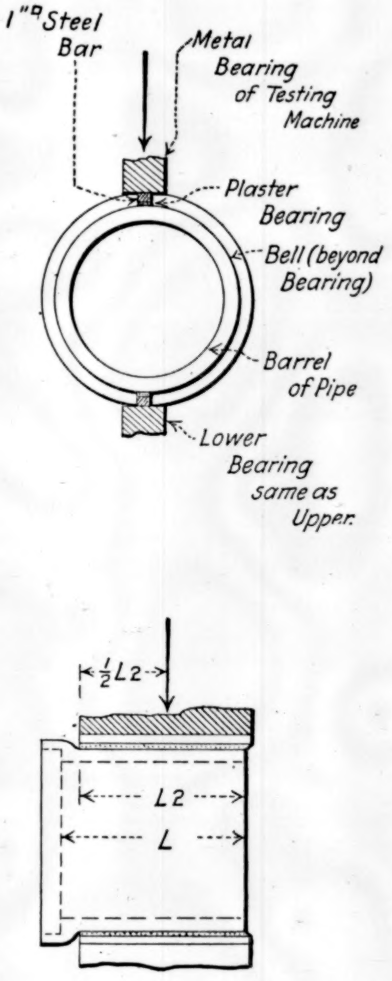
1"□ Steel Bar
Metal Bearing of Testing Machine
Plaster Bearing
Bell (beyond Bearing)
Barrel of Pipe
Lower Bearing same as Upper.
½L2
L2
L

FIG 1.—Knife or Two-Edge Bearings.

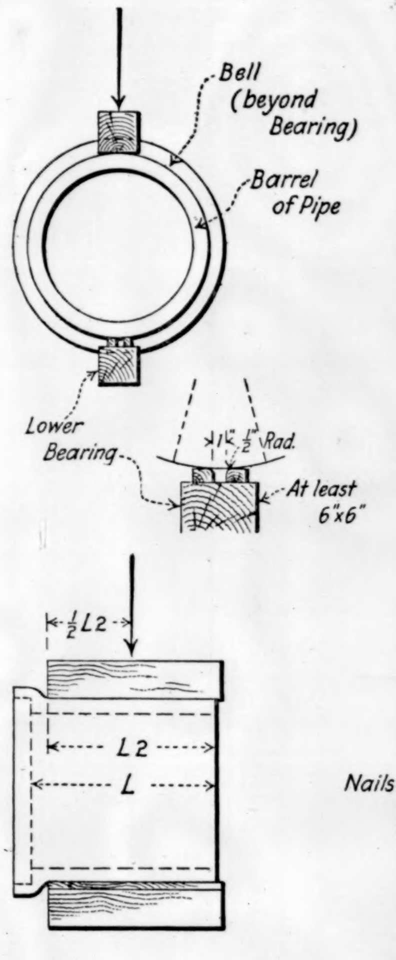
Bell (beyond Bearing)
Barrel of Pipe
Lower Bearing
1"
½" Rad.
At least 6"x6"
½L2
L2
L

FIG. 2.—Three-Edge Bearings.

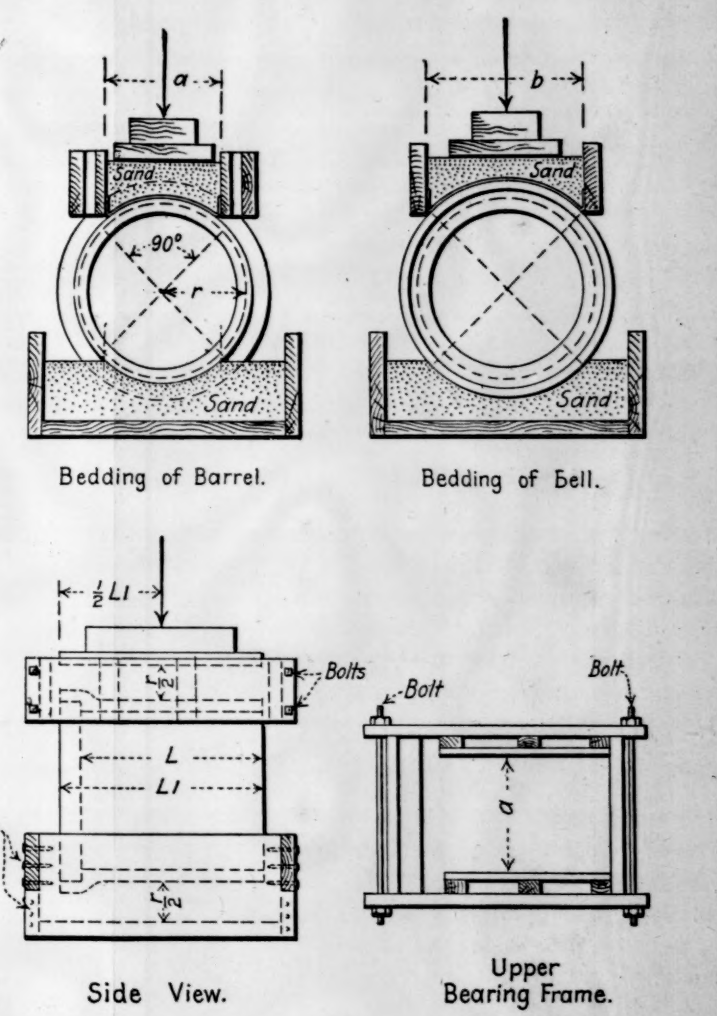
a
Sand
90°
r
Sand
Bedding of Barrel.
b
Sand
Sand
Bedding of Bell.
½L1
r/2
Bolts
L
L1
Nails
r/2
Side View.
Bolt
Bolt
a
Upper Bearing Frame.

FIG. 3.—Sand Bearings.

shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

The sand used shall be clean, and shall be such as will pass a No. 4 screen.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

Number of Specimens.

14. The crushing test shall ordinarily be applied to not less than 75 per cent of the specimens received for testing purposes.

Specimens for Absorption Test.

15. Pieces of the crushed pipe may be used as specimens in making the absorption test.

(*B*) *Hydrostatic Test.*

Hydrostatic Test.

16. Sound full-size pipe not exceeding about 25 per cent of the specimens received for test in each size of pipe, shall be tested for leakage under internal hydrostatic pressure.

The ends of the pipe shall be tightly closed by wooden or metallic bulkheads or covers faced with rubber or leather so that no leakage shall occur through the covers at the test pressure. One cover shall be provided with a $\frac{3}{4}$-in. wrought-iron nipple passing through the cover, and held securely in place and made water-tight by means of locknuts and washers or gaskets. The outer end of the nipple shall be connected with a pump discharge or water service line.

Water pressure of 5 lb. per sq. in., as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimen for 5 minutes. At the end of this period the water pressure shall be raised to 15 lb. per sq. in. and maintained for a period of 15 minutes.

The quantity of water passing through the barrel of the specimen at 15 lb. per sq. in. shall be collected and measured at the end of the test. The result shall be reported as percolation in gallons per mile in 24 hours.

(*C*) *Absorption Test.*

Test Specimens. 17. The specimens shall be sound pieces, with all edges broken, and may be from pipes broken in the crushing or other tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

Drying. 18. Preparatory to the absorption test, the specimen shall be first weighed and then dried in a drier or oven at a temperature of not less than 110° C. (230° F.) for not less than three hours. After removal from the drier, the specimen shall be allowed to cool in dry air to a temperature of 20 to 25° C. (68 to 77° F.), and then reweighed.

If the specimen is comparatively dry when taken, and the second weight closely agrees with the first, it shall be considered dry. If the specimen is wet when taken it shall be placed in the drier for a drying treatment of two hours and reweighed. If the third weight checks the second the specimen shall be considered dry. In case of any doubt, the specimen shall be redried for two-hour periods, until check weights are obtained.

Weighing. 19. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest gram. When other than metric weights are used, the same degree of accuracy shall be obtained.

Immersion. 20. The specimen, after final drying, cooling and weighing, shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15° C. (50 to 59° F.).

Reweighing. 21. The specimen shall be allowed to drain for one minute, and, the superficial moisture having been removed by towel or blotting paper, placed upon the balance.

Calculation of Absorption 22. The test result shall be calculated as percentage of the initial dry weight.

Number of Specimens. 23. One specimen shall be tested of each pipe broken in the crushing test.

Reporting Results. 24. The results shall be reported separately for each individual specimen, together with the mean for all the specimens from the same shipment of pipe.

Identification. 25. Each specimen shall be marked so that it may be identified with the pipe used in the crushing test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent of the total superficial area of the specimen.

IV. PHYSICAL TEST REQUIREMENTS.

Physical Requirements. 26. The test requirements of clay sewer pipe shall be as given in Table II. The individual results of the various tests for each size of pipe and for each shipment class and mill shall be tabulated separately so as to show the percentage which fails to comply with the requirements of each test.

V. A.S.T.M. SIZES AND DIMENSIONS.

Sizes and Dimensions. 27. Pipes shall be furnished of the sizes, internal diameter, and with the minimum dimensions given in Table III. Where several lengths are mentioned in the table the consumer or purchaser shall indicate, at the time of purchase, which lengths shall be furnished; and unless so indicated, the manufacturer shall furnish such lengths as he may elect.

Permissible Variations. 28. The permissible variation from the dimensions given in Table III shall not exceed those stated in Table IV. Where the thickness of barrel is increased beyond that given in Table IV in order to meet the specified requirements of strength, the diameter at inside of hub shall be increased by double the increase in thickness of barrel. Pipes intended to be straight shall not have variation in alignment of more than $\frac{1}{8}$ in. per foot of length.

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CLAY SEWER PIPE.

Internal Diameter, in.	Minimum Crushing Strength,[1] lb. per lin. ft.	Maximum Percolation, gal. per mile in 24 hr.	Maximum Absorption, per cent.
6	1430	These requirements will be furnished later.	5
8	1430		5
10	1570		5
12	1710		5
15	1960		5
18	2200		5
21	2590		5
24	3070		5
27	3370		5
30	3690		5
33	3930		5
36	4400		5
39	4710		5
42	5030		5

[1] See end of Section 11.

VI. WORKMANSHIP AND FINISH.

Absence of Defects. 29. Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

Scored Ends. 30. The inner surface of the hub and the outer surface of the spigot end shall be scored by triangular shaped or semicircular shaped rings about $\frac{1}{8}$ in. deep.

The number of scorings shall be as follows:

For pipes 6 to 10 in. in diameter, inclusive	2
" " 12 " 21 " " " "	3
" " 24 " 30 " " " "	4
" " 33 " 42 " " " "	5

Salt Glaze.

31. The glaze shall consist of a continuous layer of bright or semi-bright glass substantially free from coarse blisters and pimples. If present none of these shall project more than $\frac{1}{8}$ in. above the surrounding surface. Not more than 10 per cent of the inner surface of any pipe barrel shall be bare of glaze except the hub, where it may be entirely absent. Glazing will not be required on the outer surface of the barrel at the spigot end for a distance from the end equal to two-thirds the specified depth of hub for the corresponding size of pipe. Where glazing is required there shall be absence of any well-defined net work of crazing lines or hair cracks. All glazing shall be equal to that produced by the best salt-glazing process.

TABLE III.—DIMENSIONS OF CLAY SEWER PIPE.

Internal Diameter, in.	Laying Length, ft.	Diameter at Inside of Hub, in.[1]	Depth of Hub, in.	Taper of Hub.	Minimum Thickness of Barrel, in.
6	2	$8\frac{1}{4}$	2	1 : 20	$\frac{5}{8}$
8	2, $2\frac{1}{2}$, 3	$10\frac{3}{4}$	$2\frac{1}{2}$	1 : 20	$\frac{3}{4}$
10	2, $2\frac{1}{2}$, 3	13	$2\frac{1}{2}$	1 : 20	$\frac{7}{8}$
12	2, $2\frac{1}{2}$, 3	$15\frac{1}{4}$	3	1 : 20	1
15	2, $2\frac{1}{2}$, 3	$18\frac{3}{4}$	3	1 : 20	$1\frac{1}{4}$
18	2, $2\frac{1}{2}$, 3	$22\frac{1}{4}$	3	1 : 20	$1\frac{1}{2}$
21	2, $2\frac{1}{2}$, 3	26	$3\frac{1}{2}$	1 : 20	$1\frac{3}{4}$
24	2, $2\frac{1}{2}$, 3	$29\frac{1}{2}$	$3\frac{1}{2}$	1 : 20	2
27	3	$33\frac{1}{4}$	4	1 : 20	$2\frac{1}{4}$
30	3	37	$4\frac{1}{2}$	1 : 20	$2\frac{1}{2}$
33	3	$40\frac{1}{4}$	5	1 : 20	$2\frac{5}{8}$
36	3	44	5	1 : 20	$2\frac{3}{4}$
39	3	$47\frac{1}{4}$	5	1 : 20	$2\frac{7}{8}$
42	3	51	5	1 : 20	3

[1] When pipes are furnished having an increase in thickness over that given in last column, then the diameter of hub shall be increased by an amount equal to twice the increase of thickness of barrel.

Finish of Ends.

32. The ends of the pipes shall be square with their longitudinal axis.

Specials.

33. Special shapes shall have a plain spigot end and a hub end corresponding in all respects with the dimensions specified for pipes of the corresponding internal diameter. Branch pipes shall be furnished to lay the same lengths as straight pipe. All

specials shall conform in finish to the specifications for pipes given in Sections 29, 30, 31 and 32.

(*a*) Slants shall have their spigot ends cut at an angle of approximately 45 deg. with the longitudinal axis.

(*b*) Curves shall be at angles of 45, 22½, 11¼ deg., as required. They shall conform substantially to the curvature specified.

(*c*) Branches shall be furnished with the connection or connections of the size or sizes specified, securely and completely fastened by fusion in the process of vitrification to the barrel of the pipe. T-branches and double T-branches shall have the axis perpendicular to the longitudinal axis of the pipe. Y-branches, double Y-branches, and V-branches shall have their axes approximately 45 deg. from the longitudinal axis of the pipe measured from the hub end. All branches shall terminate in hubs and the barrel of the branch shall be of sufficient length

TABLE IV.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF CLAY SEWER PIPE.

Normal Size, in.	Limits of Permissible Variation in				
	Length, in. per ft. (−)	Internal Diameter, in.		Depth of Hub, in. (−)	Thickness of Barrel, in. (−)
		Spigot (±)	Hub (±)		
6	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
8	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
10	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
12	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{16}$
15	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$
18	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{3}{32}$
21	$\frac{1}{4}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$
24	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
27	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
30	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
33	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
36	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
39	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
42	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$

NOTE.—The minus sign (−) alone indicates that the plus variation is not limited; the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

to permit making a proper joint when the connecting pipesi inserted in the branch hub.

(*d*) Channel or split pipes, curves and branches shall be accurate half sections of the corresponding size of straight pipe and specials.

VII. MARKINGS.

34. Pipes shall bear the initials or name of the person, company or corporation by whom they are manufactured, and the location of the mill. The markings shall be indented on the exterior of the barrel near the hub and shall be plainly legible for purpose of identification. **Markings.**

VIII. INSPECTION.

35. All pipes shall be subject to inspection at the factory, trench or other point of delivery by a competent inspector employed by the consumer or purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to comply with the requirements of these specifications. **Inspection.**

36. Pipes shall be subject to rejection on account of the following: **Rejection.**

(*a*) Variations in any dimension exceeding the permissible variations given in Table IV.

(*b*) Fracture or cracks passing through the shell or hub, except that a single crack at either end of a pipe not exceeding 2 in. in length or a single fracture in the hub not exceeding 3 in. in width nor 2 in. in length will not be deemed cause for rejection unless these defects exist in more than 5 per cent of the entire shipment or delivery.

(*c*) Blisters where the glazing is broken or which exceed 3 in. in diameter, or which project more than $\frac{1}{8}$ in. above the surface.

(*d*) Laminations which indicate extended voids in the pipe material.

(*e*) Fire cracks or hair cracks sufficient to impair the strength, durability or serviceability of the pipe.

(*f*) Variation of more than $\frac{1}{8}$ in. per linear foot in alignment of a pipe intended to be straight.

(*g*) Glaze which does not fully cover and protect all parts of the shell and ends except those exempted in Section 31; also glaze which is not equal to best salt glaze.

(*h*) Failure to give a clear ringing sound when placed on end and dry-tapped with a light hammer.

(*i*) Insecure attachment of branches on spurs.

Marking of Rejected Specimens.

37. All rejected pipes shall be plainly marked by the inspector and shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the consumer or purchaser.

EDITORIAL NOTE.

Subsequent to its April (1917) meeting, Committee C-4 on Clay and Cement Sewer Pipe submitted to a letter ballot of the committee the question of combining the Tentative Specifications for Clay Sewer Pipe (C 13 - 17 T) and the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14 - 17 T) into one specification, or keeping them separate as now tentatively printed, with the following result: in favor of combining, 8; in favor of separating, 6; not voting, 6.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
CEMENT-CONCRETE SEWER PIPE.[1]

Serial Designation: C 14 – 17 T.

The specifications for this material are issued under the fixed designation C 14; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

1. These specifications cover cement-concrete products intended to be used for the conveyance of sewage, industrial wastes and storm water. **Scope.**

2. Pipes furnished under these specifications shall be of a single class to be designated "A.S.T.M. Cement-Concrete Sewer Pipe." **Single Class.**

I. MATERIAL AND MANUFACTURE.

3. (*a*) Cement-concrete pipes shall be manufactured from Portland-cement concrete. **Materials.**

(*b*) *Concrete.*—By concrete is meant a suitable mixture of Portland cement, mineral aggregates and water, hardened by hydraulic chemical action.

(*c*) *Cement.*—Portland cement shall meet the requirements of the Standard Specifications and Tests for Portland Cement (C 9 - 17)[1] of the American Society for Testing Materials.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipe, 170 Broadway, New York City.

(*d*) The materials shall possess such physical and chemical properties that when molded into pipes and properly cured the product will be strong, durable and serviceable, free from objectionable defects, and in compliance with these specifications and tests.

II. CHEMICAL TESTS AND REQUIREMENTS.

Chemical Tests and Requirements.

4. The consumer or purchaser may prescribe in advance special chemical requirements in cases where sewage, industrial wastes or ground waters have marked acid or alkaline character, or are of abnormally high temperatures. He may make use of chemical analysis of the pipe materials to ascertain whether these special requirements are met. The presence of deleterious materials causing slaking or disintegration shall be cause for rejection.

III. PHYSICAL TESTS.

Physical Tests.

5. The physical tests of pipes shall include: crushing test, hydrostatic pressure test and absorption test.[2]

Test Specimens.

6. The specimens to be tested shall be selected by the purchaser or his representative at the point or points designated by him when placing the order. The manufacturer or seller shall furnish specimens for test, without separate charge, up to 1 per cent of the number of pipes to be delivered or furnished in each size of pipe. The minimum number of specimens for any delivery less than 200 pieces shall be two specimens in each size of pipe.

Acceptance or Rejection on Result of Tests.

7. Failure of 20 per cent of the specimens to meet the requirements of any of the tests imposed, shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 per cent of the specimens in any size failing to meet the requirements, the manufacturer or seller may, with the consent of the consumer or purchaser, furnish for test additional specimens from the same shipment without charge. In case more than 80 per cent of the specimens tested, including those first tested,

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[1] 1916 Book of A.S.T.M. Standards, p. 429.

[2] Committee C-4 will prepare a specification also for an abrasion test.

TABLE I.—DIMENSIONS, ETC., OF CEMENT-CONCRETE SEWER PIPE FURNISHED AS TEST SPECIMENS.

Specimen No.	Date.	Job No.	Material.	Manufacturer.	Location of Factory.	Nominal Size, in.	Weight, lb.	Length, ft.	Thickness of Spigot, in.				Thickness of Hub, in.				Internal Diameter, in.						Remarks.
																	Spigot.		Back of Hub.		Hub.		
									Invert.	Crown.	Side.	Side.	Invert.	Crown.	Side.	Side.	Vertical.	Horizontal.	Vertical.	Horizontal.	Vertical.	Horizontal.	

shall show substantial compliance for each of the various tests performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected.

Measurement and Observation of Specimens.

8. The specimens of pipes shall be sound, full-size pipe. They shall first be freed from all visible moisture. When dry each specimen shall be weighed, measured and inspected. The results of these observations shall be recorded and preserved as shown in Table I.

Rejection of Defective Specimens.

9. Specimens which, when placed in a vertical position, do not give a metallic ring when struck with a hammer, or are observed to have cracks or other defects in form or dimensions in excess of the limits permitted in these specifications, shall be discarded and replaced with additional specimens from the shipment.

(*A*) *Crushing Test.*

Application of Load.

10. (*a*) Any prime mover or hand power which will apply the load at a uniform rate of about 2000 lb. per minute, or in increments of not more than 100 lb. at the same rate, may be used in making the test.

(*b*) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(*c*) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part.

(*d*) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(*e*) The load shall be applied until the pipe yields by cracks passing through the shell.

Knife or Two-Edge Bearings.

11. (See Fig. 1, Plate I.)[1].—Except as otherwise hereinafter specified, the pipe to be tested shall be supported by a metallic knife bearing 1 in. wide and extended from a point just back of the hub to the spigot end of the pipe. Before the pipe is placed a fillet of plaster of Paris and sand 1 in. wide, and thick enough to compensate for all the inequalities of the pipe barrel, shall be cast on the surface of the knife bearing. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The load shall be applied

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[1] See p. 638.

through an upper knife bearing of the same size and length as the lower bearing. A plaster-of-Paris fillet 1 in. wide shall be cast along the length of the crown of the pipe to equalize the lower bearing before the upper one is brought into contact.

Both of the bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the tests without lost motion, vibration or sudden shock.

At the option of the consumer or purchaser the crushing test may be applied with sand bearings or with two or three-edge bearings.

The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the hub to the end of the spigot; and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00

Three-Edge Bearings.

12. (See Fig. 2, Plate I.)[1].—When three-edge bearings are used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test.

The two lower bearings shall consist of two wooden strips with vertical sides, each strip having its interior top corner rounded to a radius of approximately $\frac{1}{2}$ in. They shall be straight, and shall be securely fastened to a rigid block with their interior vertical sides 1 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied through the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings.

In testing a pipe which is "out of straight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair bearings.

Sand Bearings.

13. (See Fig. 3, Plate I.)[1].—When sand bearings are used, the ends of each specimen of pipe shall be accurately marked

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[1] See p. 638.

prior to the test in quarters of the circumference. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

The sand used shall be clean, and shall be such as will pass a No. 4 screen.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

Number of Specimens.

14. The crushing test shall ordinarily be applied to not less than 75 per cent of the specimens received for testing purposes.

Specimens for Absorption Test.

15. Pieces of the crushed pipe may be used as specimens in making the absorption test.

(*B*) *Hydrostatic Test.*

Hydrostatic Test.

16. Sound full-size pipe not exceeding about 25 per cent of the specimens received for test in each size of pipe, shall be tested for leakage under internal hydrostatic pressure.

The ends of the pipe shall be tightly closed by wooden or metallic bulkheads or covers faced with rubber or leather so that no leakage shall occur through the covers at the test pressure. One cover shall be provided with a $\frac{3}{4}$-in. wrought-iron nipple passing through the cover, and held securely in place and made water-tight by means of locknuts and washers or gaskets. The outer end of the nipple shall be connected with a pump discharge or water service line.

Water pressure of 5 lb. per sq. in., as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimen for 5 minutes. At the end of this period the water pressure shall be raised to 15 lb. per sq. in. and maintained for a period of 15 minutes.

The quantity of water passing through the barrel of the specimen at 15 lb. per sq. in. shall be collected and measured at the end of the test. The result shall be reported as percolation in gallons per mile in 24 hours.

(*C*) *Absorption Test.*

Test Specimens. 17. (*a*) The specimens shall be sound pieces with all edges broken, and may be from pipes broken in the crushing or other tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

Drying. 18. Preparatory to the absorption test, the specimen shall be first weighed and then dried in a drier or oven at a temperature of not less than 110° C. (230° F.) for not less than three hours. After removal from the drier, the specimen shall be allowed to cool in dry air to a temperature of 20 to 25° C. (68 to 77° F.), and then reweighed.

If the specimen is comparatively dry when taken, and the second weight closely agrees with the first, it shall be considered dry. If the specimen is wet when taken it shall be placed in the drier for a drying treatment of two hours and reweighed. If the third weight checks the second the specimen shall be considered dry. In case of any doubt, the specimen shall be redried for two-hour periods, until check weights are obtained.

Weighing. 19. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest gram.

When other than metric weights are used, the same degree of accuracy shall be obtained.

Immersion. 20. The specimen, after final drying, cooling and weighing shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15° C. (50 to 59° F.).

Reweighing. 21. The specimen shall be allowed to drain for one minute, and, the superficial moisture having been removed by towel or blotting paper, placed upon the balance.

Calculation of Absorption. 22. The test result shall be calculated as percentage of the initial dry weight.

Number of Specimens. 23. One specimen shall be tested of each pipe broken in the crushing test.

Reporting Results. 24. The results shall be reported separately for each individual specimen together with the mean for all the specimens from the same shipment of pipe.

Identification. 25. Each specimen shall be marked so that it may be identified with the pipe used in the crushing test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent of the total superficial area of the specimen.

IV. PHYSICAL TEST REQUIREMENTS.

Physical Test Requirements. 26. The test requirements of cement-concrete pipe shall be as given in Table II. The individual results of the various tests for each size of pipe and for each shipment class and mill shall be tabulated separately so as to show the percentage which fails to comply with the requirements of each test.

V. A.S.T.M. SIZES AND DIMENSIONS.

Sizes and Dimensions. 27. Pipes shall be furnished of the sizes, internal diameter, and with the minimum dimensions given in Table III. Where several lengths are mentioned in the table the consumer or purchaser shall indicate, at the time of purchase, which lengths shall be furnished; and unless so indicated, the manufacturer shall furnish such lengths as he may elect.

Permissible Variations. 28. The permissible variation from the dimensions given in Table III shall not exceed those stated in Table IV. Where the thickness of barrel is increased beyond that given in Table III in order to meet the specified requirements of strength, the diameter at inside of hub shall be increased by double the increase in thickness of barrel. Pipes intended to be straight shall not have variation in alignment of more than $\frac{1}{8}$ in. per foot of length.

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CEMENT-CONCRETE SEWER PIPE.

Internal Diameter, in.	Minimum Crushing Strength, lb. per lin. ft.	Maximum Percolation, gal. per mile in 24 hr.	Maximum Absorption, per cent.
6	1430	These requirements will be furnished later.	8
8	1430		8
10	1570		8
12	1710		8
15	1960		8
18	2200		8
21	2590		8
24	3070		8
27	3370		8
30	3690		8
33	3930		8
36	4400		8
39	4710		8
42	5030		8

VI. WORKMANSHIP AND FINISH.

Absence of Defects. 29. Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

Finish of Ends. 30. The ends of the pipes shall be square with their longitudinal axis.

Specials. 31. Special shapes shall have a plain spigot end and a hub end corresponding in all respects with the dimensions specified for pipes of the corresponding internal diameter. Branches shall be furnished to lay the same lengths as straight pipe. All specials shall conform in finish to the specifications for pipes given in Sections 29 and 30.

(*a*) Slants shall have their spigot ends cut at an angle of approximately 45 deg. with the longitudinal axis.

(*b*) Curves shall be at angles of 45, $22\frac{1}{2}$, $11\frac{1}{4}$ deg., as required. They shall conform substantially to the curvature specified.

(*c*) Branches shall be furnished with the connection or connections of the size or sizes specified, securely and completely fastened in the process of manufacture to the barrel of the pipe. T-branches and double T-branches shall have the axis perpendicular to the longitudinal axis of the pipe. Y-branches, double Y-branches, and V-branches shall have their axes approximately 45 deg. from the longitudinal axis of the pipe measured from the hub end. All branches shall terminate in hubs and the barrel of the branch shall be of sufficient length to permit making a proper joint when the connecting pipe is inserted in the branch hub.

TABLE III.—DIMENSIONS OF CEMENT-CONCRETE SEWER PIPE.

Internal Diameter, in.	Laying Length, ft.	Diameter at Inside of Hub, in.[1]	Depth of Hub, in.	Taper of Hub.	Minimum Thickness of Barrel, in.
6	2	$8\frac{1}{2}$	2	1 : 20	$\frac{5}{8}$
8	2, $2\frac{1}{2}$, 3	$10\frac{7}{8}$	$2\frac{1}{2}$	1 : 20	$\frac{7}{8}$
10	2, $2\frac{1}{2}$, 3	$13\frac{1}{4}$	$2\frac{1}{2}$	1 : 20	1
12	2, $2\frac{1}{2}$, 3	$15\frac{1}{2}$	3	1 : 20	$1\frac{3}{16}$
15	2, $2\frac{1}{2}$, 3	$19\frac{1}{4}$	3	1 : 20	$1\frac{1}{2}$
18	2, $2\frac{1}{2}$, 3	$22\frac{3}{4}$	3	1 : 20	$1\frac{3}{4}$
21	2, $2\frac{1}{2}$, 3	$26\frac{1}{2}$	$3\frac{1}{2}$	1 : 20	2
24	2, $2\frac{1}{2}$, 3	$30\frac{1}{4}$	$3\frac{1}{2}$	1 : 20	$2\frac{3}{8}$
27	3	34	4	1 : 20	$2\frac{5}{8}$
30	3	38	$4\frac{1}{2}$	1 : 20	3
33	3	$41\frac{1}{2}$	5	1 : 20	$3\frac{1}{4}$
36	3	$45\frac{3}{4}$	5	1 : 20	$3\frac{1}{2}$
39	3	$49\frac{1}{4}$	5	1 : 20	$3\frac{3}{4}$
42	3	$53\frac{1}{4}$	5	1 : 20	4

[1] When pipes are furnished having an increase in thickness over that given in last column, then the diameter of hub shall be increased by an amount equal to twice the increase of thickness of barrel.

(*d*) Channel or split pipe, curves and branches shall be accurate half sections of the corresponding size of pipe or other specials.

VII. MARKINGS.

Markings. 32. Pipes shall bear the initials or name of the person, company or corporation by whom they are manufactured, and the location of the mill. The markings shall be indented or stenciled on the exterior or interior of the barrel near the hub and shall be plainly legible for purpose of identification.

TABLE IV.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF CEMENT-CONCRETE SEWER PIPE.

Normal Size, in.	Limits of Permissible Variation in				
	Length, in. per ft. (−)	Internal Diameter, in.		Depth of Hub, in. (−)	Thickness of Barrel, in. (−)
		Spigot (±)	Hub (±)		
6	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
8	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
10	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
12	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{16}$
15	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$
18	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{3}{32}$
21	$\frac{1}{4}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$
24	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
27	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
30	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
33	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
36	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
39	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
42	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$

NOTE.—The minus sign (−) alone indicates that the plus variation is not limited; the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

VIII. INSPECTION.

Inspection. 33. All pipes shall be subject to inspection at the factory, trench or other point of delivery by a competent inspector employed by the consumer or purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to meet the requirements of these specifications.

Rejection.

34. Pipes shall be subject to rejection on account of the following:

(*a*) Variations in any dimension exceeding the permissible variations given in Table IV.

(*b*) Fracture or cracks passing through the shell or hub, except that a single crack at either end of a pipe not exceeding 2 in. in length or a single fracture in the hub not exceeding 3 in. in width nor 2 in. in length will not be deemed cause for rejection unless these defects exist in more than 5 per cent of the entire shipment or delivery.

(*c*) Blisters where the surface is broken or which project more than ⅛ in. above the surface.

(*d*) Defects which indicate imperfect mixing and molding.

(*e*) Cracks sufficient to impair the strength, durability or serviceability of the pipe.

(*f*) Variation of more than ⅛ in. per linear foot in alignment of a pipe intended to be straight.

(*g*) Failure to give a clear ringing sound when placed on end and dry-tapped with a light hammer.

(*h*) Insecure attachment of branches on spurs.

Marking of Rejected Specimens.

35. All rejected pipes shall be plainly marked by the inspector and shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the consumer or purchaser.

EDITORIAL NOTE.

Subsequent to its April (1917) meeting, Committee C-4 on Clay and Cement Sewer Pipe submitted to a letter ballot of the committee the question of combining the Tentative Specifications for Clay Sewer Pipe (C 13 - 17 T) and the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14 - 17 T) into one specification, or keeping them separate as now tentatively printed, with the following result: in favor of combining, 8; in favor of separating, 6; not voting, 6.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
REQUIRED SAFE CRUSHING STRENGTHS OF SEWER PIPE TO CARRY LOADS FROM DITCH FILLING.[1]

Serial Designation: C 15 – 17 T.

These specifications are issued under the fixed designation C 15; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

The following table gives required safe crushing strengths per linear foot of pipe, to carry loads from ditch filling materials only when pipe is laid in accordance with the Tentative Recommended Practice for Laying Sewer Pipe (C 12–17 T) of the American Society for Testing Materials,[2] for sand and for thoroughly wet clay ditch filling materials. In the preparation of this table a safety factor of $1\frac{1}{2}$ has been used, which has been found necessary to prevent cracking from the loads of ditch filling.[3]

Ordinary Pipe Laying is pipe laying in accordance with customary good practice in pipe sewer construction, whereby the under side of the pipe is well bedded on soil for 60 to 90 deg. of the circumference.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipes, 170 Broadway, New York City.

[2] See p. 701.

[3] Prepared from the Standard Specifications for Drain Tile (C 4-16), 1916 Book of A.S.T.M. Standards, p. 452.

First Class Pipe Laying is pipe laying in accordance with the best customary practice in pipe-sewer construction, whereby the entire under side of the pipe is very thoroughly bedded on soil and the entire pipe is surrounded by well-compacted soil, under the direction of an inspector constantly present on the work.

When pipe are laid in a *Concrete or other Permanent Masonry Cradle,* strong enough to carry the entire load to the sub-base without breaking and large enough to prevent material settlement, the standard strengths for all dimensions of ditches and all filling materials shall be those specified for standard sewer pipe.

SAFE CRUSHING STRENGTHS OF SEWER PIPE TO CARRY LOADS FROM DITCH FILLING FOR ORDINARY SAND AND FOR THOROUGHLY WET CLAY DITCH FILLING MATERIALS.

(FOR ORDINARY PIPE-LAYING METHODS.)

STRENGTHS IN POUNDS PER LINEAR FOOT.

Height of Fill above Top of Pipe, ft.	Breadth of Ditch a Little Below Top of Pipe.									
	1 ft.		2 ft.		3 ft.		4 ft.		5 ft.	
	Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.	
	Sand.	Clay.	Sand.	Clay.	Sand.	Clay.	Sand.	Clay.	Sand.	Clay.
2..........	265	280	615	635	970	990	1 330	1 350	1 690	1 710
4..........	400	450	1 055	1 125	1 745	1 825	2 455	2 535	3 165	3 250
6..........	470	545	1 370	1 500	2 370	2 525	3 405	3 575	4 460	4 640
8..........	505	605	1 600	1 790	2 875	3 115	4 215	4 495	5 595	5 890
10..........	525	640	1 765	2 015	3 275	3 610	4 900	5 295	6 590	7 020
12..........	535	660	1 880	2 185	3 600	4 030	5 485	6 000	7 460	8 035
14..........	540	675	1 965	2 320	3 855	4 380	5 975	6 620	8 225	8 950
16..........	545	680	2 025	2 425	4 065	4 675	6 395	7 165	8 890	9 775
18..........	545	685	2 070	2 505	4 230	4 920	6 750	7 630	9 480	10 520
20..........	545	690	2 100	2 565	4 365	5 130	7 050	8 060	9 995	11 190
22..........	545	690	2 125	2 610	4 470	5 305	7 305	8 425	10 445	11 795
24..........	545	690	2 140	2 645	4 560	5 455	7 525	8 750	10 840	12 340
26..........	545	690	2 150	2 675	4 630	5 575	7 705	9 035	11 185	12 830
28..........	545	690	2 160	2 695	4 685	5 680	7 860	9 280	11 490	13 270
30..........	545	690	2 165	2 715	4 725	5 765	7 990	9 500	11 755	13 670
Very great	545	690	2 180	2 770	4 910	6 230	8 725	11 075	13 635	17 305

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
MASONS' HYDRATED LIME.[1]

Serial Designation: C 6 – 17 T.

The specifications for this material are issued under the fixed designation C 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Definition. 1. Masons' hydrated lime is a dry flocculent powder, resulting from the hydration of quicklime.

Uses. 2. Masons' hydrated lime may be used for making lime mortar, for scratch or brown coat of plaster, or for addition to Portland-cement mortar or concrete.

I. CHEMICAL PROPERTIES AND TESTS.

Sampling. 3. The sample shall be a fair average of the shipment. Three per cent of the packages shall be sampled. The sample shall be taken from the surface to the center of the package. A 2-lb. sample to be sent to the laboratory shall immediately be transferred to an air-tight container, in which the unused portion shall be stored until the shipment has been finally accepted or rejected by the purchaser.

Chemical Properties. 4. (*a*) The chemical composition of the hydrated lime shall be determined by standard methods of chemical analysis.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. J. S. Macgregor, Chairman of Committee C-7 on Lime, Columbia University, New York City.

These specifications, when adopted as standard, will supercede the present Standard Specifications for Hydrated Lime (C 6-15), 1916 Book of A.S.T.M. Standards, p. 472.

(*b*) *Impurities.*—The sum of the silica (SiO_2), ferric oxide (Fe_2O_3) and alumina (Al_2O_3) expressed on the sample as received shall not exceed 5 per cent.

(*c*) *Carbon Dioxide.*—Carbon dioxide in the sample as received shall not exceed 3 per cent.

(*d*) *Calcium and Magnesium Oxides.*—Calcium and magnesium oxides shall constitute not less than 90 per cent of the non-volatile portion.

II. PHYSICAL PROPERTIES AND TESTS.

Fineness.

5. (*a*) A 100-g. sample shall leave not more than 0.5 per cent of its weight on a standard 30-mesh sieve, and not more than 15 per cent of its weight on a standard 200-mesh sieve.

(*b*) The fineness test shall be made as specified in Section 11.

Constancy of Volume.

6. (*a*) A pat of mortar, covered with a skim coat of neat paste, shall be subjected to the action of steam. If the steam has no visible effect on the pat, the sample shall be reported as being "sound." If the pat disintegrates, the sample shall be reported "unsound" and the shipment rejected. If the sample cracks, pops, or shows other minor defects, it shall not be reported as either sound or unsound, but its behavior shall be noted.

(*b*) The constancy of volume test shall be made as specified in Section 12.

III. PACKING AND MARKING.

Packing.

6. (*a*) *Kind of Package.*—The hydrated lime shall be packed in either cloth or paper bags.

(*b*) *Size of Package.*—The cloth package shall contain 100 lb. net weight of hydrated lime. The paper package shall contain 50 lb. net weight of hydrated lime.

Marking.

7. Each package shall be clearly marked to show the net weight of hydrated lime contained in the package, the name of the manufacturer, and the name of the brand, if any.

IV. INSPECTION AND REJECTION.

Inspection.

8. (*a*) All hydrated lime shall be subject to inspection.

(*b*) Hydrated lime may be inspected either at the place of manufacture or the point of delivery, as arranged at the time of purchase.

(*c*) The manufacturer shall furnish the inspector all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere with the operation of the works.

(*d*) The purchaser may make the tests to govern the acceptance or rejection of the hydrated lime in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

9. Unless otherwise specified, any rejection based on failure to pass tests prescribed in these specifications shall be reported within five working days from the taking of samples.

Rehearing.

10. Samples which represent rejected hydrated lime shall be preserved in air-tight containers for five days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

V. METHODS OF TEST.

Method for Determining Fineness.

11. Fineness shall be determined as follows:

(*a*) *30-Mesh.*—Spread out a sufficient portion of the sample in a thin layer in a suitable vessel and dry to constant weight in a drying oven at a temperature between 100 and 120° C. Place 100 g. of this dried sample on a standard 30-mesh sieve and pass as much of it as possible through the sieve by shaking. The operation shall be considered completed when not more than 0.1 g. of material passes through the sieve during one minute's shaking. Collect the residue on the sieve and weigh. Calculate the weight as percentage of the dried material.

(*b*) *200-Mesh.*—Carefully collect the material which passed through the 30-mesh screen in a suitable dish and mix with enough water to form a stiff paste. Transfer this paste to a standard 200-mesh sieve and wash thoroughly with running water. A small piece of rubber tubing attached to a water faucet will be found convenient. The velocity of the stream of water can be increased by pinching the tubing, but it should not be sufficient to cause any danger of splashing the sample over the sides of the sieve. Continue the washing until the water coming through the sieve is clear. Then dry the residue to constant weight in a drying oven whose temperature is maintained between 100 and 120° C. Calculate the weight of this residue as percentage of the dried material and to the result add the percentage residue on the 30-mesh sieve. The sum of the two shall be reported as the residue on the 200-mesh sieve.

Method for Determining Constancy of Volume.

12. Constancy of volume shall be determined as follows:

To 20 g. of the sample, add 100 g. of clean, washed, graded sand which shall all pass the No. 20 sieve and which shall all be retained on the No. 100 sieve. Mix thoroughly and add enough water to make a good plastic mortar of a rather dry consistency. Spread out on a clean glass plate, to form a layer about $\frac{1}{8}$ in. thick by about 4 in. square. The pat shall be of even thickness throughout, and not tapering at the edges. If the mortar is too dry to work well, add more water. Place this pat in a closet to set for 24 hours. The temperature in the closet should be between 65 and 75° F., and there should be free circulation of air in the closet, without allowing any direct draft to hit the pat. At the end of 24 hours remove the pat from the closet and soak it in water, until a film of water stands unabsorbed on the surface of the pat. Examine the pat carefully for cracks. If any are found, too much water was used in making the pat, and it should be discarded and a new one made.

Mix 20 g. of the sample with enough water to form a thick cream. Spread this out in a thin layer on the surface of the pat. Let it stand for 15 minutes to permit possible air bubbles to form. Trowel to a smooth even surface, making this skim coat as thin as possible without allowing the sand to show through. Put the pat back in the closet for another 24 hours, so that the skim coat can set. Examine carefully, to insure the absence of any cracks or pops. Provide a vessel partially filled with cold water, and having a perforated cover. Suspend the pat in this vessel in such a way that the water can boil without touching it. Gradually bring the water to a boil, and keep it boiling gently for 5 hours, the pat being surrounded by steam during this time. Turn out the fire, and permit the water to cool for at least 12 hours before the cover is removed from the vessel. The pat is then removed and examined for cracking, popping or disintegration.

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TENTATIVE TEST
FOR
REFRACTORY MATERIALS UNDER LOAD AT HIGH TEMPERATURES[1]

Serial Designation: C 16 – 17 T.

This test is issued under the fixed designation C 16; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

1. The object of the test is to determine the resistance of the specimen to deformation at a specified temperature for a specified time, when subjected to a compressive load of 25 lb. per sq. in. (1.765 kg. per sq. cm.). **Object.**

2 The apparatus consists essentially of a furnace and loading device It shall be constructed in accordance with Figs. 1 and 2. **Apparatus.**

(*a*) The furnace shall be cylindrical in form, 14 in. (356 mm). in internal diameter, as shown in Fig. 1 (Plate II).

(*b*) The heating shall be done with gaseous or oil fuel and compressed air, using not less than two burners located tangentially and so arranged that no flame can impinge upon the test specimen. The burners shall be such as will insure a uniform temperature in all parts of the furnace and be under complete control.

(*c*) The method of loading shown in Fig. 2 shall be used, and the details shall be such as will insure accuracy in the applied load and freedom from eccentric loading, both in the original application and during the testing. It is advantageous to make the cross-beams as light as possible, so that the greater portion of the load may be concentrated in the weights.

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1918, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

(*d*) The temperature may be measured either with a calibrated platinum-rhodium thermo-couple, encased in a double protecting tube with the junction not more than 1 in. (25 mm.) from the side or edge of the specimen and approximately opposite the center; or with some form of optical pyrometer that has been calibrated against a thermo-couple in the furnace. If the thermo-couple is used, the cold-end temperature should be kept constant in melted ice. A recording form of indicator is recommended where possible.

Test Specimen.

3. The test specimen shall consist, whenever possible, of a standard 9-in. brick placed vertically on end. In the case of blocks or shapes, sections approximately 9 by 4½ by 2½ in. (228 by 114 by 64 mm.) shall be cut, utilizing as far as possible existing plane surfaces. The ends of the specimen shall be either ground so that they are parallel and perpendicular to the vertical axis, or if this is impossible, shall be bedded in a neutral cement, so that the specimen is perpendicular to the base of the furnace.

The test specimen shall be measured before testing, making not less than five observations in each direction to within ±0.02 in. (0.5 mm.). The average dimensions shall be reported, and the cross-section calculated.

Starting the Test.

4. The test specimen shall occupy approximately the center of the furnace and should rest on a block of some highly refractory material, having a minimum expansion or contraction. A silicon-carbide brick has been found satisfactory. At the top of the test specimen a block of similar highly refractory material should be placed, extending through the furnace top to receive the load.

Heating.

5. The method of heating shall be in accordance with Table I, which gives the rate and time of heating suggested for different grades of material.

PLATE II.
PROC. AM. SOC. TEST. MATS.
VOLUME XVII, PART I.

TENTATIVE TEST FOR REFRACTORY MATERIALS.

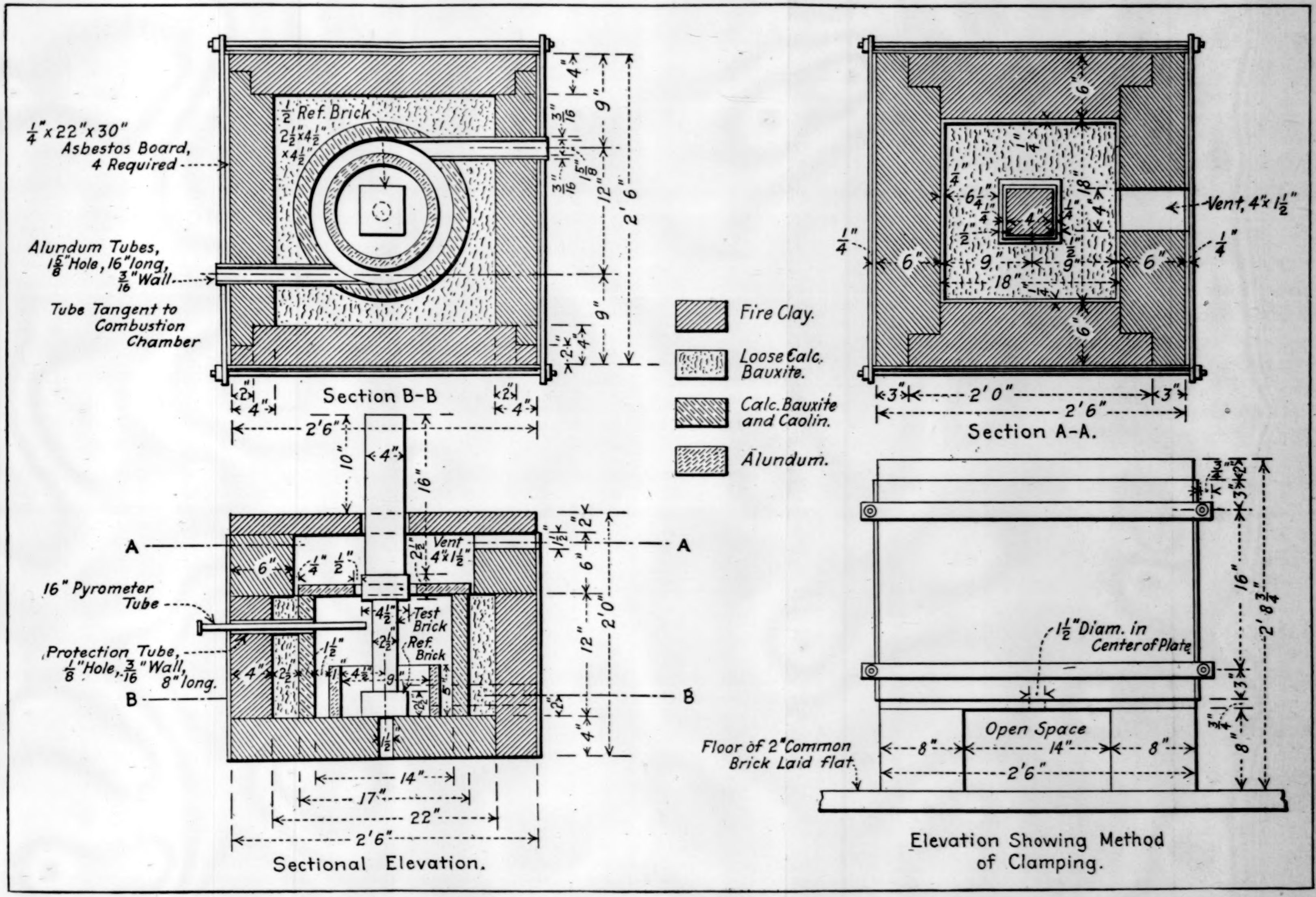
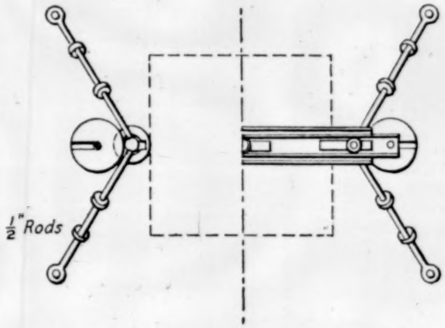
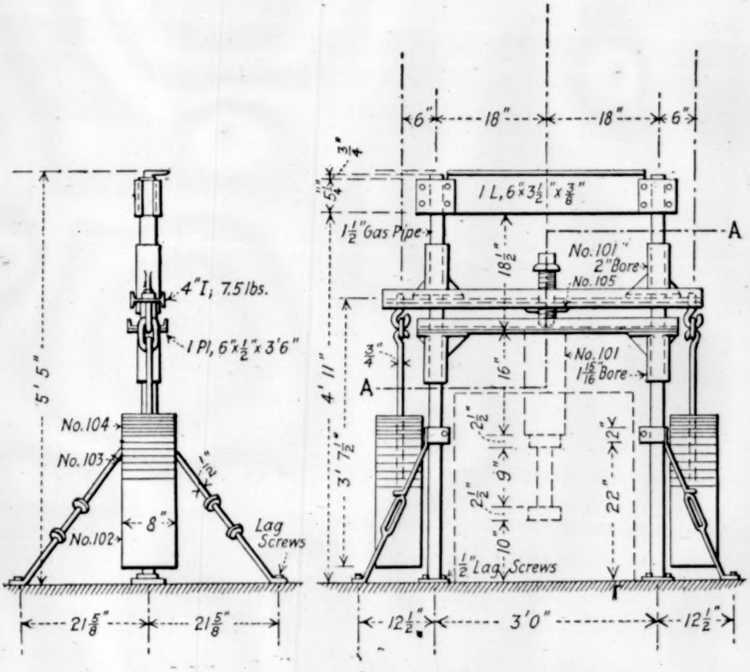

1/4"x22"x30" Asbestos Board, 4 Required
1/2 Ref. Brick 2 1/2"x4 1/2"x4 1/2"
Alundum Tubes, 1 5/8" Hole, 16" long, 3/16" Wall
Tube Tangent to Combustion Chamber
Section B-B
2'6"
Section A-A.
Vent, 4"x1 1/2"
2'0"
Fire Clay.
Loose Calc. Bauxite.
Calc. Bauxite and Caolin.
Alundum.
A
B
16" Pyrometer Tube
Protection Tube, 1/8" Hole, 3/16" Wall, 8" long.
Test Brick
Ref. Brick
Vent 4"x1 1/2"
Sectional Elevation.
1 1/2" Diam. in Center of Plate
Open Space
Floor of 2" Common Brick Laid flat
2'8 3/4"
Elevation Showing Method of Clamping.

FIG. 1.—Apparatus for Testing Refractory Materials under Load at High Temperatures.



Section A-A


6"
18"
18"
6"
¾"
5¼"
1 L, 6"×3½"×⅜"
1½" Gas Pipe
A
No. 101 2" Bore
No. 105
18½"
4' 11"
16"
No. 101 1 15/16" Bore
A
4¾"
2½"
9"
2½"
10"
12"
22"
3' 7½"
½" Lag Screws
12½"
3'0"
12½"
5' 5"
4" I, 7.5 lbs.
1 Pl, 6"×½"×3'6"
No. 104
No. 103
No. 102
8"
½"
Lag Screws
21⅝"
21⅝"

End Elevation. Side Elevation.

FIG. 2.—Method of Loading.

TABLE I.—TEMPERATURES FOR HEATING AT VARIOUS PERIODS.

Material.		Temperatures, in deg. Cent., to be Maintained at the Time Intervals Specified.					
		1 hr.	2 hr.	3 hr.	4 hr.	$4\frac{1}{2}$ hr.	6 hr. (End of Test)
Silica Material		200	500	900	1350	1500	1500
Fire Clay	Heavy Duty	500	900	1150	1300	1350	1350
	Moderate Duty	500	850	1100	1250	1300	1300
	Light Duty	500	750	950	1050	1100	1100

Loading.

6. (*a*) The load is calculated from the average cross-section as determined on the untested specimen and the requirement of the test. It is recommended that for general purposes, 25 lb. per sq. in. (1.765 kg. per sq. cm.) be used.

(*b*) The additional masses required to give the desired loading should be equally distributed on each side of the beam.

Completing the Test.

7. (*a*) At the expiration of the time of heating, the supply of heat shall be stopped and the furnace allowed to cool, during not less than 5 hours before removing the load and examining the test specimen.

(*b*) After the test specimen has cooled to the room temperature, it shall be remeasured as before described, and the change in length recorded and reported as percentage of the original length.

(*c*) It is recommended that a photograph be made of the specimen before and after testing, as yielding valuable information at a minimum time and expense.

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TENTATIVE TEST
FOR
SLAGGING ACTION OF REFRACTORY MATERIALS.[1]

Serial Designation: C 17 – 17 T.

This test is issued under the fixed designation C 17; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

1. Select three or more of the bricks to be tested. Draw upon the smooth or unbranded side a line bisecting each brick across the narrow dimension. Draw diagonals across each half. At the points of intersection of the diagonals drill circular cavities $2\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. deep on the sides. The drill used shall be $\frac{5}{16}$ in. in thickness, the point shall be tapered to include an angle of 150 deg., and the width of the bit shall be such as to cut a hole $2\frac{1}{2}$ in. in diameter. The cavity after drilling shall be checked up by a standard template, and shall conform to the same as nearly as the nature of the material permits. All loose material, dust and cuttings shall be carefully removed from each cavity. **Preparation of Samples.**

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1918, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

Preparation of the Slag to be Used as a Solvent.

2. A slag,[1] selected with reference to the purpose for which the bricks are to be used, shall be employed as the solvent. This slag shall be ground until it will pass a 40-mesh sieve

The Heat Treatment.

3. The bricks shall be placed level on the hearth of a cold furnace and heated to 1350° C., attaining this temperature in a time not shorter than 5 hours Thirty-five grams of powdered slag shall then be introduced by a metal spoon or equivalent device, avoiding scattering it upon the margins of the cavity. The temperature shall then be held as nearly as possible at 1350° C. for 2 hours; the fluctuations should not exceed 10° C., above or below this point. The furnace shall then be allowed to cool without removing the bricks.

Measuring the Penetration.

4. When cold, the bricks shall be sawed so that one of the sawed surfaces accurately bisects the center of the original cavity.[2] The slag will be found to have discolored the brick into which it has penetrated more or less deeply. For measuring the area affected, a planimeter is used. The extreme outer margin of the discolored area shall be traced with the planimeter, and the unaffected upper portion of the original cavity also circumscribed. From the area in square inches thus obtained deduct the area of the original cavity, 1.7 sq. in.; the difference is the area of the brick penetrated and discolored by the slag.

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[1] The slags used in the development of this test were selected as representing the iron and steel industry and were of the following chemical composition:

	BLAST-FURNACE SLAG.	HEATING-FURNACE SLAG.	OPEN-HEARTH SLAG.
Silica (SiO_2), per cent	38.0	35.0	18.4
Iron (Fe), per cent	1.5	44.0	14.5
Manganese (Mn), per cent	1.0	0.5	5.1
Alumina (Al_2O_3), per cent	14.5	6.0	3.8
Lime (CaO), per cent	42.0	1.5	44.1
Magnesia (MgO), per cent	2.0	0.5	6.3
Sulfur (S), per cent	1.0	...	0.4

[2] The wheel used for sawing the brick is a carborundum wheel, 12 in. in diameter, ⅛ in. thick, 1¼ in. diameter of center hole, grit 16, bond NCH. This wheel is known as a vulcanite wheel.

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TENTATIVE METHODS FOR ULTIMATE CHEMICAL ANALYSIS OF REFRACTORY MATERIALS.[1]

Serial Designation: C 18 – 17 T.

These methods are issued under the fixed designation C 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Prefatory Note.—It will be understood that the making of a complete silicate analysis is a difficult procedure requiring a wide knowledge of the chemistry involved in the operations, and a thorough training in carrying out the work. A skilled analyst of good training is therefore required to do the work. The descriptions here given cover the vital points of procedure, but frequent reference in regard to the details of the various manipulations must be made to *Bulletin No. 422*, United States Geological Survey on "Analysis of Silicate and Carbonate Rocks," by W. F. Hillebrand; also, to "Treatise on the Ceramic Industries," Vol. 1 (1913), by J. W. Mellor; and to similar publications.

I. GENERAL CONSIDERATIONS.

Grinding of Sample.

1. The sample shall be crushed in a hardened tool-steel mortar, using a pestle of the same sort. Fine grinding shall be done in an agate mortar, either by hand, or by a mechanical sample grinder of the McKenna, Carling or similar type, so constructed as to prevent the introduction of impurity.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1918, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Pittsburgh, Pa.

Statement of Analysis.

2. Moisture shall be determined in the sample in its ordinary air-dried condition, and all other percentage compositions shall be calculated to a moisture-free basis. Whenever a sample is weighed out for any determination, a moisture determination shall also be made.

Checking Results.

3. In all cases, check determinations shall be made, and the results shall be redetermined if satisfactory checks are not obtained. It shall be considered satisfactory if the differences between check determinations do not exceed the following limits:

For silica or other constituent amounting to 30 per cent or over	0.3 per cent
For alumina or other constituent amounting to 10–30 per cent	0.2 per cent
For any other constituent amounting to under 10 per cent	0.1 per cent

These figures are stated in terms of the whole sample as 100 per cent.

II. SOLUTIONS REQUIRED.

Concentrated Acids.

4. The acids referred to as concentrated shall be of approximately the following specific gravities:

Hydrochloric Acid (HCl)	1.20
Sulfuric Acid (H_2SO_4)	1.84
Nitric Acid (HNO_3)	1.42

Ammonium Carbonate.

5. Dissolve 1.5 g. of ammonium carbonate in 50 cc. of cold water.

Ammonium Chloride.

6. Dissolve 107 g. of NH_4Cl in 1000 cc. of warm water.

Ammonium Nitrate.

7. Neutralize 20 cc. of concentrated HNO_3 with NH_4OH and dilute to 1000 cc. Test with litmus; the solution shall not be acid.

Ammonium Oxalate.

8. Dissolve 1 g. of ammonium oxalate in 50 cc. of water, heating gently.

Standard-Titania Solution.

9. The strength of the final standard titania solution shall be 1 cc. = 0.0001 g. TiO_2. To prepare the solution weigh out in a platinum crucible an amount of potassium titanium fluoride

(K_2TiF_6) sufficient to make from ½ to 1 liter of "stock solution" in which 1 cc. = 0.001 g. TiO_2. Evaporate several times with H_2SO_4 without taking to dryness, thus driving out all fluorine. Take up the residue with water containing enough H_2SO_4 to make at least 5 per cent of the solution, when finally diluted to the standard solution strength. To standardize the stock solution take out two 50-cc. portions, dilute, boil and precipitate with ammonia. Filter, wash with hot water until free from alkali, ignite, blast and weigh. The duplicate should check very closely. From the weight of titania thus determined calculate the strength of the stock solution. The standard solution to be used is obtained from the stock solution by diluting until 1 cc. = 0.0001 g. (TiO_2).

Standard Potassium-Permanganate Solution.

10. Dissolve about 0.4 g. (a little less) of $KMnO_4$ in 1 liter of water and check against an iron solution of known purity and strength. Dilute the solution until 1 cc. = 0.001 g. Fe_2O_3.

III. METHODS.

MOISTURE.

Moisture.

11. To determine moisture, heat approximately 1 g. of the sample at a temperature not under 105 nor over 110° C., to constant weight.

IGNITION LOSS.

Ignition Loss.

12. To determine loss on ignition, heat about 1 g. of the sample over a blast lamp or in an electric furnace at 900 to 1000° C., to constant weight. Ignition loss may be determined in the sample from which the moisture has been removed. The percentage of ignition loss is calculated to a moisture-free basis.

SILICA.

Silica.

13. To determine silica, weigh out approximately 0.5 g. of the sample and mix with 5 g. of Na_2CO_3. Put a little Na_2CO_3 in the bottom of the crucible before introducing the mixture, and then cover the mixture with a little more Na_2CO_3. Fuse over a Meker burner or blast lamp until complete solution is obtained. Cool the fusion and as it solidifies, rotate the crucible to spread the mass up the side walls. Dissolve the fusion in about 100 cc.

of water in a platinum or porcelain evaporating dish. Add about 20 cc. of concentrated HCl, introducing it slowly by means of a pipette, keeping the dish covered with a watch glass. Evaporate to dryness and heat until the fumes of HCl are gone. Add about 5 cc. of concentrated HCl and 30 to 40 cc. of water. Warm on a water bath for 10 to 15 minutes and break up the lumps. Decant the clear liquid onto a filter paper and collect the filtrate in a 400-cc. beaker. Add more HCl and water to the evaporating dish, warm again and decant. Repeat this a third time.

Finally transfer the contents of the dish to the filter paper. Wash with cold water until silver nitrate shows no chlorides to be left. Transfer the filtrate to the original evaporating dish, evaporate again to dryness and wash as before. Transfer to a platinum crucible. Ignite carefully over a Bunsen flame until the filter paper is burned off, then blast for about 30 minutes; cool and weigh. Repeat blasting for 5 minutes, weigh again and repeat until constant weight is obtained.

To the residue in the crucible, add about 5 cc. of water and 5 drops of H_2SO_4 (the latter to prevent the formation of titanium fluoride). Evaporate to dryness. Again moisten with about 5 cc. of water and 5 drops of H_2SO_4. Add HF drop by drop at first, and then slowly until the crucible is almost one-half filled. Warm on a hot plate until almost dry, add 2 or 3 cc. more of HF and evaporate to dryness. Heat the crucible to bright redness and then blast for 5 minutes. Cool and weigh and repeat blasting to constant weight. The loss in weight from the original silica residue represents the actual silica content (SiO_2), except for that part of silica which is later recovered from alumina, etc. The residue from the HCl evaporation is left in the crucible and the total precipitate of alumina, etc., is added to this same crucible in which it is ignited and weighed.

ALUMINA.

Alumina. 14. To determine alumina, to the filtrate from the silica determination, add about 10 cc. of NH_4Cl solution and heat to boiling. Then add NH_4OH very slowly and with constant stirring until there is a slight excess. Filter hot and rapidly, and wash four times by decantation with hot solution of ammonium nitrate. Carefully wash the precipitate from the filter paper into a beaker, using hot water. Dissolve the precipitate in hot dilute HCl. Repeat the precipitation with NH_4Cl and NH_4OH. Decant four times as before, using hot ammonium nitrate. Transfer to the filter paper and wash with hot ammonium nitrate until the washings are free from chlorides when tested by silver nitrate. Evaporate the filtrate nearly to dryness, add a little NH_4OH and continue the evaporation. Keep the solution alkaline to coagulate any iron and aluminum hydroxides. Transfer the precipitate to a filter paper and wash thoroughly. Transfer the moist filter paper to the platinum crucible containing the residue from the silica. Burn off the filter paper and blast the precipitate. Cool in a desiccator and then moisten with one drop of HNO_3 and heat gently until all fumes are gone. Blast again and weigh. Repeat blasting and weighing to a constant weight.

IRON OXIDE.

Iron Oxide.

15. To determine iron oxide, fuse the ignited alumina precipitate with about six times its weight of potassium pyrosulfate or potassium bisulfate. Avoid sputtering. Heat carefully to redness and continue heating until the residue is all dissolved. Cool. Dissolve in warm water and add about 10 cc. of dilute H_2SO_4 (1 : 5). Evaporate to a small volume. Then heat to a higher temperature until copious fumes of H_2SO_4 are evolved. Sufficient H_2SO_4 should be present to form a pasty mass when cooled. Take up with water, filter off, wash, ignite and weigh the silica as before and evaporate with HF as before. The loss in weight is extra silica to be added to the original silica determination and subtracted from the alumina. Fuse the residue with a little potassium pyrosulfate or potassium bisulfate, and add the solution of this cake to the main solution. Transfer the total filtrate to a 250-cc. graduated flask and dilute to 250 cc., mixing thoroughly. Draw off 50 cc. of this solution and reserve for titania determination. Pass the remaining 200 cc. through a Jones reductor, or otherwise reduce the solution with pure zinc and H_2SO_4. To the solution add 3 cc. of 10-per-cent $CuSO_4$ solution and titrate with standard $KMnO_4$ solution (1 cc. equivalent to 0.001 g. Fe_2O_3), until a faint pink tinge is seen. If Jones reductor or

similar apparatus is used, subtract the $KMnO_4$ equivalent, which has previously been determined on blank samples run through the apparatus. From the result, calculate the iron as Fe_2O_3.

TITANIA.

Titania. 16. To determine titania, place in a small Nessler tube the 50 cc. of filtrate previously set aside for titania determination, and fill the tube up to the graduation mark. Add 1 cc. of H_2O_2 and shake well. The color of this solution is now compared in any standard color comparator with the color of a known standard solution, preferably of such strength that 1 cc. equals 0.0001 g. of titanium dioxide (TiO_2). To make the comparison, put 10 cc. of this standard solution into a second small Nessler tube and dilute with water from a burette until the color is matched. Note the amount of water added and calculate the percentage of TiO_2 in the sample.

LIME.

Lime. 17. To determine lime, evaporate the filtrate from the alumina precipitation to about 250 cc. While still boiling add about 5 cc. of acetic acid. Meanwhile, dissolve about 1 g. of oxalic acid in a little hot water and add to the solution. In about 5 minutes add a slight excess of NH_4OH and boil until precipitation is complete. Cool thoroughly and filter. Wash three times by decantation with dilute NH_4OH (1 : 10) or a 1-per-cent solution of ammonium oxalate. Dissolve the precipitate by adding about 50 cc. of dilute HNO_3 (1 : 5). Again add a slight excess of NH_4OH and a few drops of oxalic-acid solution. Boil well and let stand a couple of hours to cool. Filter and wash as before. Transfer the precipitate to a platinum crucible, carefully burn off the paper and ignite over a blast lamp for about 10 minutes. Cool and weigh quickly. Repeat the blasting to constant weight. The increase in weight of crucible is calcium oxide.

MAGNESIA.

Magnesia. 18. To determine magnesia, add to the filtrate from lime precipitation about 2 g. of sodium-ammonium-phosphate dissolved in 15 cc. of water. Stir vigorously and while stirring add drop by drop about one-third of the volume of the solution of NH_4OH. Let stand 12 to 24 hours. Filter and wash the precipitate with dilute NH_4OH (1 : 10). Discard the filtrate. Wash the precipitate until the washings show no discoloration when tested with silver nitrate. Redissolve the precipitate in warm dilute HNO_3 (1 : 5), using about 50 cc., and collect in a beaker. Precipitate and wash as before. Collect the precipitate on a Gooch asbestos crucible. Dry slowly and then heat over a Meker burner for about 10 minutes; cool and weigh. Reignite to constant weight.

ALKALIES.

Alkalies.

19. To determine alkalies, the J. Lawrence Smith method shall be used. Weigh out about 0.5 g. of the sample and mix well with 0.5 g. of NH_4Cl and 3 g. of $CaCO_3$. Transfer to a platinum crucible, placing about 0.5 g. of $CaCO_3$ in the bottom of the crucible and a similar amount over the top of the mixture. Heat gently over a low flame for about 15 minutes to volatilize NH_4Cl. Then raise the temperature until the lower three-quarters of the crucible is dull red. Hold this temperature for about one hour. Cool, take up with about 50 cc. of water and heat over a water bath, adding water to replace that lost by evaporation. Break up any lumps with a small pestle. Decant the clear liquid through a filter paper and wash four times by decantation. Then transfer the residue to the filter. Wash until silver nitrate shows only a very faint turbidity. To the filtrate add NH_4OH and ammonium carbonate and heat to boiling. Filter and again digest the precipitate with NH_4OH and ammonium carbonate. Filter and allow the filtrate to collect with the previous filtrate, then evaporate to dryness in a platinum or porcelain dish. Remove ammonium salts by gentle ignition in a moving flame. Treat with water and remove the last trace of lime by adding ammonium oxalate to the boiling solution and let stand over night. Filter, evaporate to dryness, ignite gently and allow to cool. Then moisten the residue with HCl, evaporate again to dryness, ignite gently and weigh. The increase in weight is $KCl+NaCl$. Dissolve in water. Ignite and weigh any insoluble residue, deducting this from the mixed chlorides.

Dilute the solution of the mixed chlorides and add hydrochloroplatinic acid in amount equal to 0.3 cc. more than would be necessary if all chlorides were present as KCl. Evaporate to a syrupy consistency. Cool and treat with a few cubic centimeters of 80-per-cent ethyl alcohol. Stir and decant through a weighed Gooch crucible. Treat again with 80-per-cent alcohol and decant. Repeat washing and decantation until the alcohol leaving the Gooch crucible is colorless and the precipitate appears golden yellow, not orange. Transfer the precipitate to the Gooch crucible, wash with 80-per-cent alcohol about six times and dry at 130° C. to constant weight. This residue is potassium chloroplatinate.

The oxides are calculated as follows:

Weight of potassium chloroplatinate $\times 0.3068 = KCl$.
Weight of potassium chloroplatinate $\times 0.1941 = K_2O$.
Total chlorides $- KCl = NaCl$.
$NaCl \times 0.5303 = Na_2O$.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHOD
FOR
CONTROL OF FIRE TESTS AND CLASSIFICATION OF MATERIALS AND CONSTRUCTION AS DETERMINED BY TEST.[1]

Serial Designation: C 19 - 17 T.

This method is issued under the fixed designation C 19; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

METHOD FOR CONTROL OF FIRE TESTS.

The conduct of fire tests of materials and construction shall be controlled by the tentative "Standard Time-Temperature Control Curve" shown in Fig. 1. The points on the curve which determine its character are indicated on the plot.

The temperatures fixed by the curve shall be deemed to be the average temperature given by several thermo-couples (not less than three) distributed over the surface of the test sample, and situated at distances of 6 in. from the sample.

NOTE.—Committee C-5 on Fireproofing is desirous that practical applications of the curve to tests be made with the object of ascertaining what changes, if any, may be advisable, and also what permissible temperature variations should be allowed.

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[1] Criticisms of the suitability of the curve for the purpose intended and of the proposed classification, are solicited, and should be directed to Mr. Ira H. Woolson, Chairman of Committee C-5 on Fireproofing, 76 William St., New York City.

CLASSIFICATION OF MATERIALS AND CONSTRUCTION AS DETERMINED BY TEST.

Fire-resistive materials and construction shall be classified into three or more grades based upon the degree of protection they afford when measured by a fire test conducted in accordance with the tentative "Standard Time-Temperature Control Curve."

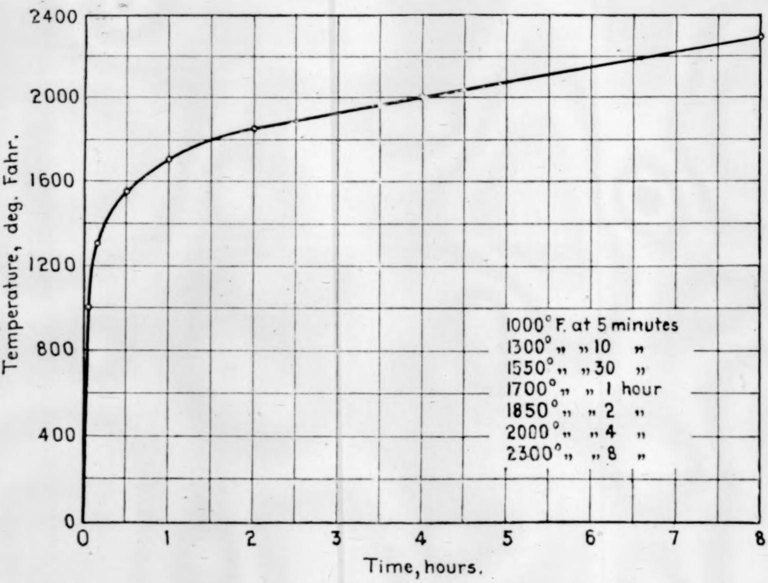

FIG. 1.—Tentative Standard Time-Temperature Control Curve for Fire Tests of Building Construction.

The classes shall be designated as follows:

Materials or Construction which afford One-Hour Protection
" " " " " Two " "
" " " " " Three " "
" " " " " Four " "

Other classes shall be interpolated or added as may become necessary.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY.[1]

Serial Designation: C 11 – 16 T.

These definitions are issued under the fixed designation C 11; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

SYNOPSIS.

These definitions are divided into fifteen parts, under the following titles:

I. GYPSUM: ITS FORMS, FUNCTIONS AND PRODUCTS.

Giving the various forms in which gypsum is used, its functions in the various classes of products, and a list of these products classified according to these functions.

II. CEMENTITIOUS BASE PRODUCTS.

A development of the products classified according to the first function given under Part I.

III–VII.

A skeleton outline of the development of products classified according to the remaining functions given under Part I.

VIII. CLASSES, TYPES AND FORMS OF CEMENTITIOUS BASE PRODUCTS.

A development of the classes, types and forms of the products given in

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[1] Criticisms of these Tentative Definitions are solicited and should be directed, preferably before January 1, 1918, to Mr. R. J. Wig, Chairman of Committee C-11 on Gypsum, Bureau of Standards, Washington, D. C.

Part II. The plan is to give the definition of each product as it is listed, it being the intention that this arrangement will show the reason for the adoption of certain terms, and for the avoidance of other terms.

IX–XIII.

To be a development, similar to Part VIII, of the classes, types and forms of the products given in Parts III–VII.

XIV. GLOSSARY.

Contains a list of the ingredients used in gypsum products with their definitions, and a list of terms the use of which should be avoided if possible.

XV. APPENDIX.

Contains a discussion of the reasons for the adoption or avoidance of all of the foregoing terms.

I. GYPSUM: ITS FORMS, FUNCTIONS AND PRODUCTS.

(*A*) FORMS.

Forms. 1. Gypsum is used in the arts in two forms:

- (*a*) Uncalcined.
    - (1) Mass.
    - (2) Crushed.
    - (3) Ground.
- (*b*) Calcined.

(*B*) FUNCTIONS.

Functions. 2. Gypsum is used to function in several distinct ways:

- (*a*) As a cementitious base.
- (*b*) As a chemical.
- (*c*) As a pigment.
- (*d*) As a filler.
- (*e*) As a flux.
- (*f*) As a (other functions to follow).

(*C*) PRODUCTS.

Products. 3. Gypsum is mixed with other materials in the following classes of products:

- (*a*) As a cementitious base in
    - (1) Coatings—applied in plastic form.
    - (2) Bondings—applied in plastic form.

- (3) Structural products.
- (4) Cast products.
- (5) Pottery products.

(*b*) As a chemical in

- (1) Fertilizers.
- (2) Portland-cement manufacture.
- (3) Sulfuric-acid manufacture.
- (4) Brewing industry.

(*c*) As a pigment in

- (1) Paints, oil, or water.

(*d*) As a filler in

- (1) Paper.
- (2) Cloth.

(*e*) As a flux in

- (1) Brass melting.

(*f*) As a carrier for

- (1) Paris green.

II. CEMENTITIOUS BASE PRODUCTS.

(*A*) COATINGS.

Coatings.

4. Coatings applied in a plastic form are sub-divided as follows:

(*a*) *Plaster.*—A material used in a plastic state to form a hard covering for the *interior* surfaces, walls, ceilings, etc., of any building or structure. The word "plaster" is used without regard to the composition of the material, defining only its use and location of use as contrasted with the words "stucco" and "mortar."

For Gypsum Plaster, see Part VIII, Section 22 (*c*) *1*.

(*b*) *Stucco.*—A material used in a plastic state to form a hard covering for the *exterior* walls or other *exterior* surfaces of any building or structure. The word "stucco" is used without regard to the composition of the material, defining only its use and location of its use, as contrasted with the words "plaster" and "mortar."

For Gypsum Stucco, see Part VIII, Section 22 (*c*) *2*.

(*B*) BONDINGS.

Bondings.

5. Bondings applied in a plastic form are sub-divided as follows:

(*a*) *Mortar.*—A material used in a plastic state, becoming hard in place, to bond together such materials as brick, stone, tile, gypsum blocks, terra cotta, etc., in building walls, partitions, columns, foundations, piers, floors, and roof arches, etc. The word "mortar" is used without regard to the composition of the material, defining its use as a bonding material, as contrasted with the words "stucco" and "plaster."

For Gypsum Mortar, see Part VIII (*B*)—(Definition to follow.)

(*C*) STRUCTURAL PRODUCTS.

Structural Products.

6. Gypsum structural products are sub-divided as follows:
(Definitions to follow.)

(*a*) *Gypsum Plaster Boards.*
(*b*) *Gypsum Blocks* are sub-divided as follows:
  (1) Floor tile.
  (2) Book tile.
  (3) Roof tile.
  (4) Partition blocks.
  (5) Furring tile.
  (6) Column covering.
(*c*) *Concrete* is sub-divided as follows:
  (1) Arches—floor and roof.

(*D*) CAST PRODUCTS.

Cast Products.

7. Gypsum cast products are sub-divided as follows:
(Definitions to follow.)

(*E*) POTTERY PRODUCTS.

8. Gypsum pottery products are sub-divided as follows: **Pottery Products.**

(Definitions to follow.)

III. CHEMICAL PRODUCTS.

(*A*) FERTILIZERS.

9. Gypsum fertilizers are sub-divided as follows: **Fertilizers.**

(Definitions to follow.)

(*B*) PORTLAND-CEMENT MANUFACTURE.

10. The uses of gypsum in Portland-cement manufacture may be sub-divided as follows: **Portland-Cement Manufacture.**

(Definitions to follow.)

(*C*) SULFURIC-ACID MANUFACTURE.

11. The uses of gypsum in sulfuric-acid manufacture may be sub-divided as follows: **Sulfuric-Acid Manufacture.**

(Definitions to follow.)

(*D*) (Title to follow.)

12. The uses of gypsum in (another chemical process) may be sub-divided as follows:

(Definitions to follow.)

IV. PIGMENT PRODUCTS.

(*A*) COATINGS APPLIED WITH BRUSH.

13. Liquid gypsum coatings applied with a brush are sub-divided as follows: **Coatings Applied with Brush.**

(Definitions to follow.)

(*B*) (Title to follow.)

14. (Another pigment product) are sub-divided as follows:

(Definitions to follow.)

V. FILLER PRODUCTS.

(*A*) PAPER FILLERS.

Paper Fillers.

15. Gypsum paper fillers are sub-divided as follows:

(Definitions to follow.)

(*B*) CLOTH FILLERS.

Cloth Fillers.

16. Gypsum cloth fillers are sub-divided as follows:

(Definitions to follow.)

(*C*) (Title to follow.)

17. Gypsum (other fillers) are sub-divided as follows:

(Definitions to follow.)

VI. FLUX PRODUCTS.

(*A*) FOUNDRY-CORE FLUXES.

Foundry-Core Fluxes.

18. Gypsum foundry-core fluxes are sub-divided as follows:

(Definitions to follow.)

(*B*) (Title to follow.)

19. Gypsum (other fluxes) are sub-divided as follows:

(Definitions to follow.)

VII. (Other) PRODUCTS.

(*A*) (Title to follow.)

20. Gypsum (other products) are sub-divided as follows:

(Definitions to follow.)

(*B*) (Title to follow.)

21. Gypsum (other products) are sub-divided as follows:

(Definitions to follow.)

VIII. CLASSES, TYPES AND FORMS OF CEMENTITIOUS BASE PRODUCTS.

(*A*) COATINGS.

Classes of Coatings.

22. *Classes.*—Gypsum coatings applied in plastic form (plasters and stuccoes) are divided into several classes depending upon the predominating cementitious material, as follows:

(*a*) *Lump-Lime Plaster and Stucco.*

1. *Lump-Lime Plaster.*—A plaster in which the predominating cementitious material is lime putty made by slaking quicklime at the job.
2. *Lump-Lime Stucco.*—A stucco in which the predominating cementitious material is lime putty made by slaking quicklime at the job.

(*b*) *Hydrated-Lime Plaster and Stucco.*

1. *Hydrated-Lime Plaster.*—A plaster in which the predominating cementitious material is hydrated lime. It may be either "job-mixed plaster" or "prepared plaster." (See Section 23.)
2. *Hydrated-Lime Stucco.*—A stucco in which the predominating cementitious material is hydrated lime. It may be either "job-mixed stucco" or "prepared stucco." (See Section 23 (*a*)*2*, or (*b*)*2*.)

(*c*) *Gypsum Plaster and Stucco.*

1. *Gypsum Plaster.*—A plaster in which the predominating cementitious material is calcined gypsum.

   (Frequently called "cement plaster," "hard wall plaster," "patent plaster," "calcined plaster," "rock-wall plaster," "stucco wall plaster," etc. The use of these terms should be avoided.)

2. *Gypsum Stucco.*—A stucco in which the predominating cementitious material is calcined gypsum.

(*d*) *Keene's-Cement Plaster and Stucco.*

1. *Keene's-Cement Plaster.*—A plaster in which the predominating cementitious material is Keene's cement.
2. *Keene's-Cement Stucco.*—A stucco in which the predominating cementitious material is Keene's cement.

(*e*) *Portland-Cement Plaster and Stucco.*

1. *Portland-Cement Plaster.*—A plaster in which the predominating cementitious material is Portland cement.
2. *Portland-Cement Stucco.*—A stucco in which the predominating cementitious material is Portland cement.

(*f*) *Natural-Cement Plaster and Stucco.*

1. *Natural-Cement Plaster.*—A plaster in which the predominating cementitious material is natural cement.
2. *Natural-Cement Stucco.*—A stucco in which the predominating cementitious material is natural cement.

Forms of Coatings.

23. *Forms.*—Plasters and stuccoes are divided into several forms depending upon the amount of mixing done at the mill of the producer as follows:

(*a*) *Job-Mixed Plaster and Stucco.*

1. *Job-Mixed Plaster.*—A plaster in which all the ingredients are mixed at the job.
2. *Job-Mixed Stucco.*—A stucco in which all the ingredients are mixed at the job.

(*b*) *Prepared Plaster and Stucco.*

1. *Prepared Plaster.*—A plastering material mixed at the mill by the producer with all the constituent parts in their proper proportion, with the exception of the aggregate which may or may not be incorporated with the mixture at the mill.

   Prepared plasters are sub-divided into "ready-mixed plasters" and "neat plasters." See definition of these plasters.
2. *Prepared Stucco.*—A stucco material mixed at the mill by the producer with all the constituent parts in their proper proportion, with the exception of the aggregate which may or may not be incorporated with the mixture at the mill.

   Prepared stuccoes are sub-divided into "ready mixed stucco" and "neat stuccoes." See definitions of these stuccoes.

3. *Ready-Mixed Plaster.*—A "prepared plaster" requiring only the addition of water to make it ready for use.

   This term distinguishes "ready-mixed plaster" from "neat plaster."

4. *Ready-Mixed Stucco.*—A "prepared stucco" requiring only the addition of water to make it ready for use.

   This term distinguishes "ready-mixed stucco" from "neat stucco."

5. *Neat Plaster.*—A "prepared plaster" requiring the addition of both the aggregate and water to make it ready for use.

   This term distinguishes "neat plaster" from "ready-mixed plaster."

6. *Neat Stucco.*—A "prepared stucco" requiring the addition of both the aggregate and water to make it ready for use.

   This term distinguishes "neat stucco" from "ready-mixed stucco."

24. *Types.*—Plasters and stuccoes are divided into several types depending upon the following conditions: **Types of Coatings.**

(*a*) *Material Used as an Aggregate.*

1. *Sand Plaster and Sand Stucco.*

   Sand Plaster.—A plaster in which sand is used as the aggregate. This expression is used without regard to either the cementitious material employed, or the place of mixing the ingredients.

   This term distinguishes "sand plaster" from "pulp plaster."

   Sand Stucco.—A stucco in which sand is used as the aggregate. This expression is used without regard to either the cementitious material employed, or the place of mixing the ingredients.

   This term distinguishes "sand stucco" from "pulp stucco."

2. *Pulp Plaster and Pulp Stucco.*

   Pulp Plaster.—A plaster in which pulp is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

This expression distinguishes "pulp plaster" from "sand plaster."

Pulp Stucco.—A stucco in which pulp is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

This expression distinguishes "pulp stucco" from "sand stucco."

3. Fiber Plaster and Fiber Stucco.

Fiber Plaster.—A plaster in which fiber is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

Fiber Stucco.—A stucco in which fiber is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

(*b*) *Number of Coats.*

1. Two-Coat Work. (Definition to follow.)

2. Three-Coat Work. (Definition to follow.)

First or Scratch Coat.—The first coat of plaster or stucco. It is applied directly to the lath or masonry surfaces to be covered, and is scratched before thoroughly dry to provide a better bond for the next coat.

Second or Browning Coat.—The second coat of plaster or stucco. Generally used only in three-coat work, but does sometimes mean the finishing coat in two-coat work.

(*c*) *Method of Application.*

1. Dry Scratch Work. (Definition to follow.)

2. Doubled-up Work. (Definition to follow.)

3. Drawn Work. (Definition to follow.)

(*d*) *Finish.*—The finish given to a plastered or stuccoed surface is sub-divided as follows:

Finish or White Coat.—The last coat of plaster or stucco. In three-coat work it is applied to the second coat, and in two-coat work it is applied to the first coat, and then sometimes known as the second coat.

1. *White Troweled or Smooth Finish.* (Definition to follow.)
2. *Sand-Float or Rough Finish.* (Definition to follow.)
3. *Pebble Dash Finish.* (Definition to follow.)
4. *Stippled Finish.* (Definition to follow.)

(*B*) BONDINGS.

Development of Part II (*B*), Section 5. Definitions to follow.

(*C*) STRUCTURAL PRODUCTS.

Development of Part II (*C*), Section 6. Definitions to follow.

(*D*) CAST PRODUCTS.

Development of Part II (*D*), Section 7. Definitions to follow.

(*E*) POTTERY PRODUCTS.

Development of Part II (*E*), Section 8. Definitions to follow.

IX. CLASSES, TYPES AND FORMS OF CHEMICAL PRODUCTS

Development of Part III, Sections 9–12. Definitions to follow.

X. CLASSES, TYPES AND FORMS OF PIGMENT PRODUCTS.

Development of Part IV, Sections 13–14. Definitions to follow.

XI. CLASSES, TYPES AND FORMS OF FILLER PRODUCTS.

Development of Part V, Sections 15–17. Definitions to follow.

XII. CLASSES, TYPES AND FORMS OF FLUX PRODUCTS.

Development of Part VI, Sections 18–19. Definitions to follow.

XIII. CLASSES, TYPES AND FORMS OF (Other) PRODUCTS.

Development of Part VII, Sections 20–21. Definitions to follow.

XIV. GLOSSARY.

(*A*) DEFINITIONS OF INGREDIENTS OF GYPSUM PRODUCTS.

1. *Gypsum.*—Gypsum is a hydrous calcium sulfate, formula $CaSO_4.2H_2O$, which may contain varying percentages of silica, alumina, iron oxide, and carbonates of calcium and magnesium.

   Limitations as to percentages of impurities should be established.

2. *Uncalcined Gypsum.*—A synonym for gypsum.

   Generally used to mean the raw material as taken from the mine or quarry for commercial use.

3. *Mass Gypsum.*—(Definition to follow.)

4. *Crushed Gypsum.*—A form of uncalcined gypsum. The size (state size limitations), distinguishing it from "ground gypsum."

5. *Ground Gypsum.*—A form of uncalcined gypsum. The size (state size limitations), distinguishing it from "crushed gypsum."

6. *Calcined Gypsum.*—A product resulting from the partial or complete calcination of gypsum. A cementitious material often used in stuccoes, plasters, mortars, concretes, etc., as the active setting material.

   Chemically pure calcined gypsum has the formula $CaSO_4.H_2O$. The commercial material has the same impurities as gypsum; silica, alumina, iron oxide, and carbonates of calcium and magnesium. Limitations as to percentage of impurities should be established. Frequently called "Plaster of Paris," the use of which should be avoided. (See Part XIV, Glossary, Section 29.)

7. *Cement.*—A material or a mixture of materials having cementitious properties (as hydrated lime, Portland cement, calcined gypsum, natural cement, glue, asphalt, Keene's cement, etc.). The word "cement" is used without regard to the composition of the material, and does not define its use or location of use as do the words "stucco," "plaster" and "mortar."

8. *Concrete.*—A mixture of one or more cementitious materials (as Portland cement, hydrated lime, calcined gypsum, natural cement, etc.), with an aggregate of sand, broken stone, cinders, asbestos fiber, etc., which becomes a solid mass when the cementitious materials have hardened.

9. *Portland Cement.*—The product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

   Definition taken from Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.[1]

10. *Natural Cement.*—The finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the caronbic acid gas.

   Definition taken from Standard Specifications for Cement (Serial Designation: C 10) of the American Society for Testing Materials.[1]

11. *Keene's Cement.*—(Definition to follow.)

12. *Quicklime.*—A material the major part of which is calcium oxide or calcium and magnesium oxide, which will slake on the addition of water.

   Definition taken from Standard Specifications for Quicklime (Serial Designation: C 5) of the American Society for Testing Materials,[1] where it is divided into two forms, "lump" and "pulverized." See definitions of "lump lime" and "pulverized lime."

   Also known as "lime," "lump lime," "burned lime," "calcinde lime," the use of which terms should be avoided.

13. *Lump Lime.*—A form of quicklime. The size taken from the kiln without crushing or grinding, distinguishing it from "pulverized lime."

   Definition taken from Standard Specifications for Quicklime (Serial Designation: C 5) of the American Society for Testing Materials.[1] The form of quicklime generally slaked at the job tc make "lime putty."

14. *Pulverized Lime*—A form of quicklime; "lump lime" reduced in size to pass a $\frac{1}{4}$-in. screen, distinguishing it from "lump lime."

   Definition taken from Standard Specifications for Quicklime

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[1] See 1916 Book of A.S.T.M. Standards.

(Serial Designation: C 5) of the American Society for Testing Materials.[1] This form of quicklime is seldom slaked at the job to produce "lime putty."

15. *Hydrated Lime.*—A cementitious material often used in stucco, plaster, mortar, etc., as an active setting agent. Always prepared at the mill of the producer and never made at the job from quicklime.

The definition given in the Standard Specifications for Hydrated Lime (Serial Designation: C 6) of the American Society for Testing Materials[1] is as follows: "A dry flocculent powder resulting from the hydration of quicklime." Analysis required by these specifications permits only the amount of water necessary to satisfy chemical hydration. This makes production of hydrated lime impossible at the job.

16. *Lime Putty.*—The predominating cementitious material in lime plaster, lime stucco and lime mortar. Made by slaking "quicklime" with an excess of water, or by adding water to "hydrated lime." A white, cream-like, smooth plastic paste.

Also called "slaked lime," the use of which term should be avoided.

17. *Lime Paste.*—A synonym of "lime putty."
18. *Aggregate.*—The inert materials used as a filler in stucco, plaster, mortar, concrete mixtures, without regard to their function as a binding material.
19. *Fine Aggregate.*—(Definition to follow.)
20. *Filler.*—A synonym for "aggregate."
21. *Sand.*—(Definition to follow.)
22. *Pulp.*—A binder used in stucco and plaster. Made by grinding, crushing or shredding wood in a manner similar to that in preparing wood pulp in paper manufacture. One of the general classes of fiber binders.
23. *Binder.*—A material used in stucco and plaster to increase the tensile strength, intended to prevent cracking and crumbling.
24. *Fiber.*—A general class of material used as binders in stucco and plaster. May be of wood, asbestos, hemp, etc.
25. *Hair.*—A binder used in stucco and plaster. Obtained from goats, cattle or other animals. One of the general class of fiber binders.

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[1] See 1916 Book of A.S.T.M. Standards.

26. *Asbestos.*—(Definition to follow.)
27. *Retarders.*—Any material used in stucco, plaster, mortar, concrete, etc., to reduce the rapidity with which the cementitious materials set.
28. *Accelerators.*—Any material used in stucco, plaster, mortar, concrete, etc., to increase the rapidity with which the cementitious materials set.

(*B*) TERMS, THE USE OF WHICH SHOULD BE AVOIDED IF POSSIBLE.

29. *Plaster-of-Paris.*—This term uses "plaster" in a sense not in agreement with the definition. Also, this material is wrongly considered to be plaster, resulting in misunderstandings. "Calcined gypsum" is the term that should be used. (See Part XIV, Glossary, Section 6.)
30. *Cement Plaster.*—The term lacks definiteness, as it has been used to mean both "gypsum plaster" and "Portland-cement plaster."
31. *Hard Wall Plaster.*—See Part XV, Appendix, Section 20.
32. *Rock Wall Plaster.*—See Part XV, Appendix, Section 20.
33. *Patent Plaster.*—See Part XV, Appendix, Section 20.
34. *Calcined Plaster.*—See Part XV, Appendix, Section 20.
35. *Stucco Plaster.*—See Part XV, Appendix, Section 20.
36. *Wall Plaster.*—See Part XV, Appendix, Section 20.
37. *Stucco Wall Plaster.*—See Part XV, Appendix, Section 20.
38. *Ceiling Plaster.*—See Part XV, Appendix, Section 20.
39. *Dry Mortar.*
40. *Bag Mortar.*
41. *Plaster Mortar.*
42. *Stucco Mortar.*
43. *Lime.*—It has been misused to mean any cementitious lime material without regard to its chemical or physical nature, and now lacks specific meaning. Chemically pure lime (CaO) is seldom used in the arts. See definition of "quicklime."
44. *Burned Lime.*—See definition of "quicklime," Part XIV, Glossary, Section 12.
45. *Calcined Lime.*—See definition of "quicklime," Part XIV, Glossary, Section 12.
46. *Slaked Lime.*—See definition of "lime putty" or "lime paste," Part XIV, Glossary, Sections 16 or 17.
47. *Building Lime.*—See definition of "quicklime," "lump lime," "pulverized lime," "hydrated lime," Part XIV, Glossary, Sections 12–15.
48. *Land Plaster.*

APPENDIX.

XV. DEVELOPMENT OF DEFINITIONS.

(*A*) STUCCO.

Stucco. 1. The word "stucco" is derived from the old High German word "stuchhi" meaning "a crust" or "piece."

2. Webster's Unabridged Dictionary defines the "stucco" as "plaster of any kind used as a coating for walls; especially a fine plaster, composed of lime or gypsum, sand and pounded marble, used for internal decorations and fine work." From this it appears that "stucco" may mean a coating for either exterior or interior walls, with particular reference to interior ornamental work as moldings, cornices, etc.

3. Manufacturers have used the word stucco to mean different materials without regard to the location of the surface to which it is applied. The following shows how "stucco" has been used by various manufacturers.

(*a*) Atlas Wall Plaster Co., Louisville, Ky., produce "Atlas Stucco Finish" for interior finish only, which is a calcined gypsum product.

(*b*) Michigan Gypsum Co., Grand Rapids, Mich., produce "N. P. Brand Stucco" for interior finish only, which is a calcined gypsum product.

(*c*) Plymouth Gypsum Co., Fort Dodge, Iowa, produce "Plymouth Rock Stucco," use not given, but probably for *exterior* work; which is a calcined gypsum product.

(*d*) The Associated Metal Lath Manufacturers have defined "stucco" as referring solely to a covering of an exterior wall without regard to the composition of the material.

(*e*) Monument Plaster Co., Harrison, N. J., produce "Oriental Stucco," a material for exterior finish only. This is a lime product.

(*f*) The Association of American Portland Cement Manufacturers have prepared Bulletin No. 22 on Portland-Cement Stucco. In this Bulletin "stucco" is used to mean a covering of an exterior wall only.

4. An examination of other literature in which the word "stucco" is used shows the following:

(*a*) Mr. Edwin C. Eckel, C.E., in his book on "Cements, Limes and Plasters" considers "stucco" as a synonym for Plaster of Paris without definition as to its use in exterior or interior work

(*b*) Many books describing exterior treatments for buildings by applying coatings of cementitious materials, use the word "stucco" in describing the materials.

(*c*) The paint manufacturers that produce materials for coloring, dampproofing and weatherproofing stucco use the word "stucco" to mean the material used to coat an exterior wall.

(*d*) Among architects, building contractors, and building owners, the word "stucco" has grown to mean an exterior wall covering or coating.

5. Consequently, it is advisable to discontinue the use of the word "stucco" to describe a covering material for an interior surface; since, where the greatest study of the materials for exterior surface covering has been made, "stucco" has been used to differentiate this use of material from all others.

(*B*) PLASTER.

6. The word "plaster" is derived from the Greek and Latin words meaning "to daub on" or "to stuff in." **Plaster.**

7. Webster's Unabridged Dictionary defines "plaster" as "a composition of lime, water and sand with or without hair as a bond, for coating walls, ceilings and partitions of houses;" also as "calcined gypsum or plaster of Paris, especially when ground, as used for making ornaments, figures, moldings, etc."

8. For many years, plasters have been divided into two classes, interior and exterior plasters, depending upon the location or exposure of the surface to which the material is applied. Exterior plaster is better defined as "stucco" and should be so called. As a result, the above distinction is not necessary and by elimination, "plaster" means but one thing, namely: a coating for interior surface not exposed to weather.

9. Objection to this limitation in the definition of plaster will perhaps be made by those who use the term "exterior plaster" rather than stucco and the few using "stucco" to mean a special form of material for interior work.

10. It will be noted that the definition of "plaster" proposed in Part II, Section 4 (*a*), does not include uses of the material not given in either the root of the word or in its dictionary definition. The proposed definition merely limits the meaning of the word in order to make it a foundation on which can be built a collection of terms that will accurately describe the many various materials and mixtures used in plastering.

11. This restricted use of the word "plaster" will prevent the present confusion between plasters and the materials used in making plaster, and make clear at once the designed use of the material. Evidence of this confusion is found in the expression "Plaster of Paris," which to many has meant "plaster." The preceding definitions have shown that this material is not plaster, but rather is "calcined gypsum," which it should be called. Other confusing expressions are "stucco wall plaster," and "stucco plaster," which have been used in the past without regard to the location of the use of the material, and mean either interior or exterior wall covering material depending only upon the connection in which they are used or the nature of the product produced by the manufacturer marketing the materials. All these and similar misunderstandings are obviated by using the suggested definitions for "plaster" and "stucco."

(*C*) MORTAR.

Mortar. 12. The word "mortar" is derived from the Latin word "mortarium," meaning a vessel in which substances are pounded or rubbed, and later the pounded or rubbed substances.

13. Webster's Unabridged Dictionary defines the word as "a building material made by mixing lime, cement or plaster of Paris with sand, water and sometimes other materials; used in masonry for joining stones, bricks, etc., also for plastering and in other ways." From this it appears that "mortar" means the same as that given in preceding paragraphs for stucco, plaster, and mortar.

14. The use of the word "mortar" as given in Part II, Section 5 (*a*), adds no new meaning, but restricts it to a particular use, rendering unnecessary such expressions as "stucco mortar,"

"plaster mortar," etc. It will also remove the confusion resulting from using the same expression to define materials used in making stuccoes, plasters and mortars.

(*D*) PLASTERS AND PLASTERING MATERIALS.

Plasters and Plastering Materials.

15. A careful distinction should be made between plaster and the materials used to make plaster. For instance, hydrated lime may or may not be mixed with sand or other aggregates and a binder to make plaster. In this case, if the plaster is used for scratch or brown coat work, no one individual material is plaster, but the completed mixture is plaster. It is obvious that the aggregate or fiber, even when water is added, does not constitute plaster; consequently the hydrated lime in this case is not justly considered plaster, as it is a part of the mixture in the same manner that the aggregate and binder are parts of the mixture. However, in finishing coat work, if calcined gypsum is not added to gage the mixture, the hydrated lime is plaster.

16. The statements in Section 15 are not contradictory when the definition for "plaster" in Part II, Section 4 (*a*), is carefully considered. Also, this distinction will cause no confusion in practice, as hydrated lime, or even calcined gypsum, is seldom used alone in finishing coat work, the two materials being mixed together to make finishing coat plaster.

17. An examination of literature descriptive of this class of plaster shows a confusing variety of different expressions, all of which are used in naming the same materials used for the same purpose. Some of these terms and the producers using them are as follows:

Cement Plaster is used by:

Plaster Manufacturers' Assoc.
U. S. Gypsum Co.
Michigan Gypsum Co.
Overland Gypsum Co.
American Gypsum Co.
Southern Gypsum Co.
Atlas Wall Plaster Co.
Texas Cement Co.
Arden Plaster Co.
Crown Gypsum Co.
Plymouth Gypsum Co.
Manitoba Gypsum Co.
American Cement Plaster Co.
Rock Plaster Mfg. Co.
J. B. King & Co.
The Alabastine Co.
Acme Cement Plaster Co.
Wotherspoon Plaster Mills, Inc.

18. From this list, which is only representative, it is evident that in the central and western parts of this country "cement plaster" is very generally used to mean "gypsum plaster." Without doubt, many people must think that "gypsum or calcined gypsum" means the same as "cement." This understanding must cause much confusions as there are a large number of people who consider cement to mean Portland, Rosendale, Keene's, etc., cement.

19. The suggested use of the terms "gypsum plaster" (Part VIII, Section 22 (*c*) *1*) and "cement" (Part XIV, Glossary, Section 7) will prevent many misunderstandings.

20. *Hard Wall Plaster*, *Rock Wall Plaster*, *Patent Plaster*, *Calcined Plaster*, *Wall Plaster*, *Stucco Wall Plaster*, etc., are some of the expressions used to mean the material that has been defined as "gypsum plaster." These expressions have not been as generally used as "cement plaster," and of themselves may not have produced misunderstandings, since, with the exception of "stucco wall plaster," they have not been construed to mean other materials than "gypsum plaster." The expression "gypsum plaster" has an advantage over all these terms in that it denotes the particular cementitious material that is used in causing the plaster to harden.

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TENTATIVE RECOMMENDED PRACTICE FOR LAYING SEWER PIPE.[1]

Serial Designation: C 12 – 17 T.

This recommended practice is issued under the fixed designation C12; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915; REVISED, 1916, 1917.

I. PREPARING TRENCHES AND FOUNDATIONS FOR PIPE LAYING.

The foundations in the trench should be formed to prevent any subsequent settlement and thereby possibly an excessive pressure and consequent rupture of the pipes.

If the foundation is rock an equalizing bed of concrete or sand well compacted should be placed upon the rock. The thickness of these beds should be not less than 4 in. Pipes should be laid in these beds so that at least the lower third of each pipe is supported its entire length.

If the foundation is good firm earth, the earth should be pared or molded to give a full support to the lower third of each pipe and, if necessary to secure a proper bearing for the pipe, a layer of concrete, fine gravel or other suitable material should be placed. The same means of securing a firm foundation should be adopted in case the excavation has been made deeper than necessary.

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[1] Criticisms of this Tentative Recommended Practice are solicited and should be directed, preferably before January 1, 1918, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipes, 170 Broadway, New York City.

If there is no good natural foundation, the pipes should be laid in a concrete cradle supported on a masonry foundation carried to a soil of satisfactory bearing power or supported on a structure designed to carry the weight of pipe and its load to a firm bearing.

Trenches should be kept free from water until the material in the joints and masonry has sufficiently hardened.

To protect pipe lines from unusual stresses all work should preferably be done in open trenches.

Pipe lines should be placed at a sufficient depth below the surface of the street to avoid dangerous pressure or impact. When this is not possible special reinforcement should be provided.

Trenches should be only of sufficient width to provide a free working space on each side of the pipe, preferably of not over one-third of the nominal diameter, and never less than 4 in., according to the size of the pipe and the character of the ground; but in every case there should be sufficient space between the pipe and the sides of the trench to make it possible to thoroughly ram the back-filling around the pipe and to secure tight joints.

II. PIPE LAYING.

The laying of pipes in finished trenches should be commenced at the lowest point, so that the spigot ends point in the direction of flow.

All pipes should be laid with ends abutting and true to line and grade. They should be fitted and matched so that when laid in the work they will form a sewer with a smooth and uniform invert.

It is necessary to use all possible care when shoving the pipes together, so that the joints will not be unnecessarily large.

Bells should be carefully cleaned before pipes are lowered into trenches. The pipes should be so lowered as to avoid unnecessary handling in the trench.

The pipes should be set firmly accordingly to line and grade, and the joints carefully adjusted and filled with the jointing material.

Joints should be made in the following manner: A closely twisted hemp or oakum gasket of suitable diameter, in no case less than $\frac{3}{4}$ in., and in one piece of sufficient length to pass around the pipe and lap at the top, should be solidly rammed into the annular spaces between the pipes with a suitable calking tool. When cement joints are used, the gasket should first be saturated with neat cement grout. The remainder of the space should then be completely filled with the jointing materials.

III. BACKFILLING TRENCHES.

All trenches and excavations should be backfilled immediately after the pipes are laid therein, unless other protection of the pipe line is directed. The backfilling material should be selected and deposited with special reference to the future safety of the pipes. Clean earth, sand or rock dust should be solidly tamped about the pipes up to a level at least 2 ft. above the top of the pipes. This material should be carefully deposited in uniform layers. Unless otherwise permitted, each layer should be carefully and solidly tamped or rammed with proper tools so as not to injure or disturb the pipe line.

Puddling or water flooding for consolidating the backfilling is recommended only for sandy and gravelly materials. If this method is used, the first flooding should be applied after the backfilling has been compacted by tamping up to 2 ft. above the top of the pipes, and the second flooding during or after the subsequent filling of the trench. An excess of water should be avoided, in order to prevent disturbance of the earth under and around the pipes and also to prevent an undue excess of pressure upon them.

Walking or working on the completed sewer, except as may be necessary in tamping or backfilling, should not be permitted until the trench has been backfilled to a height of at least 2 ft. over the top of the pipes.

The filling of the trench should be carried on simultaneously on both sides of the pipes in such a manner that injurious side pressures do not occur.

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TENTATIVE SPECIFICATIONS FOR SELECTED STRUCTURAL DOUGLAS FIR BRIDGE AND TRESTLE TIMBERS.[1]

Serial Designation: D 23 - 16 T.

The specifications for this material are issued under the fixed designation D 23; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

I. DEFINITIONS.

Definitions. 1. The following definitions are used in connection with these specifications:

(*a*) *Annual Ring.*—Each annual ring is composed of two distinct types of wood structure, namely, the porous, light colored and light weight spring wood formed during the first part of the growing season and the hard, dense and darker colored summer wood formed during the latter part of the growing season.

(*b*) *Summer Wood.*—Summer wood is the hard, dense portion of the annual ring. It is darker in color than the more porous spring wood.

(*c*) *Sound and Tight Knot.*—A sound and tight knot is one which is solid across its face and which is as hard as the wood surrounding it; and is so fixed by growth or position that it will retain its place in the piece.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

(*d*) *Encased Knot.*—An encased knot is one whose growth rings are not intergrown and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain its place in the piece, it shall be considered a sound and tight knot.

(*e*) *Loose Knot.*—A loose knot is one not firmly held in place by growth or position.

(*f*) *Rotten Knot.*—A rotten knot is one not as hard as the wood it is in.

(*g*) *Measurement of Knots.*

In Beams, the diameter of a knot on the narrow or horizontal face shall be taken as its projection on a line perpendicular to the edge of the timber. On the wide or vertical face, the smallest dimension of a knot is to be taken as its diameter.

In Columns, the diameter of a knot on any face shall be taken as its projection on a line perpendicular to the edge of the timber.

(*h*) *Diagonal Grain.*—(Including cross and spiral grain). Diagonal grain is grain not parallel with all the edges of the piece.

(*i*) *Dense and Sound DouglasFir.*—Under this heading two classes of timber are designated: (1) Dense Douglas fir and (2) sound Douglas fir. It is understood that these two terms are descriptive of the quality of the clear wood.

(*j*) *Dense Douglas Fir.*—Dense Douglas fir shall show on either one end or the other an average of at least 6 annual rings per inch or 18 rings in three inches and at least 33⅓ per cent summer wood, as measured over the third, fourth and fifth inches on a radial line from the pith, for girders not exceeding 20 in. in height, and for columns 16 in. square or less. For larger timbers the inspection shall be made over the central three inches on the longest radial line from the pith to the corner of the piece. Wide-ring material excluded by the above will be accepted provided the amount of summer wood as above measured shall be at least 50 per cent.

In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over three inches on an approximate radial line beginning at the edge nearest the pith.

The radial line chosen shall be representative. In case of disagreement between purchaser and seller as to what is a representative radial line, the average summer wood and number of rings shall be the average of the two radial lines chosen.

(*k*) *Sound Douglas Fir.*—Sound Douglas fir shall include pieces of Douglas fir without any ring or summer wood requirement.

II. GENERAL REQUIREMENTS.

General Requirements.

2. (*a*) The timber shall be only "Dense Douglas Fir" as defined in Section 1 (*j*).

(*b*) The timber shall be well manufactured, square edge and sawed standard size; solid and free from defects such as ring shakes and injurious diagonal grain, loose or rotten knots, knots in groups, decay, pitch pockets over 6 in. long or $\frac{3}{8}$ in. wide, or other defects that will materially impair its strength.

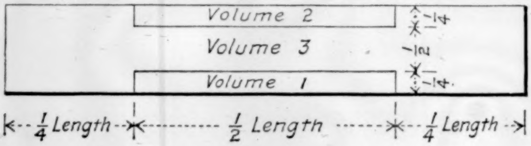

FIG. 1.

(*c*) Occasional variation in sawing, not to exceed $\frac{1}{4}$ in. scant at the time of manufacture, will be allowed.

(*d*) When timbers 4 by 4 in. and larger are ordered sized, they shall be $\frac{1}{2}$ in. less than rough size, either S1S1E or S4S, unless otherwise specified.

III. STRINGERS, GIRDERS AND DEEP JOISTS.

Stringers, Girders and Deep Joists.

3. The timber shall show not less than 85 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece. It shall not have in volumes 1 and 2 (Fig. 1) knots greater in diameter than one-fourth the width of the face in which they occur with a maximum of $1\frac{1}{2}$ in. in diameter. It shall not have in volume 3 (Fig. 1) knots larger than one-third the width of the face in which they occur, with a maximum of 3 in. in diameter. Knots within the center half

of the span shall not exceed in the aggregate the width of the face in which they occur. Diagonal grain in volumes 1 or 2 with a slope greater than 1 in 20 will not be permitted. When stringers are of two-span length they shall be considered as two separate pieces and the above restrictions applied to each half. The inspector shall place his stamp on the edge of the stringer to be placed "up" in service.

IV. CAPS AND SILLS.

Caps and Sills.

4. The timber shall show 85 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece, and shall be free from knots larger than one-fourth the width of the face in which they occur, with a maximum of 3 in. in diameter. Knots shall not be in groups.

V. POSTS.

Posts.

5. The timber shall show not less than 85 per cent of heart on each of the four sides, measured across the face anywhere in the length of the piece, and shall be free from knots larger than one-fourth the width of the face in which they occur, with a maximum of 3 in. in diameter. Knots shall not be in groups.

VI. LONGITUDINAL STRUTS OR GIRTS.

Longitudinal Struts or Girts.

6. The timber shall show all heart on one face; the other face and two sides shall show not less than 85 per cent of heart, measured across the face or side anywhere in the length of the piece, and shall be free from knots over 2 in. in diameter.

VII. LONGITUDINAL X-BRACES, SASH BRACES AND SWAY BRACES.

Longitudinal X-Braces, Sash Braces and Sway Braces.

7. The timber shall show not less than 85 per cent of heart on two faces and shall be free from knots larger than one-third the width of the face in which they occur, with a maximum of 2 in. in diameter.

VIII. BRANDING.

Branding.

8. The inspector shall brand each timber which conforms to the above requirements "Selected Structural Douglas Fir."

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PHILADELPHIA, PA., U. S. A.

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TENTATIVE SPECIFICATIONS
FOR
SOUTHERN YELLOW-PINE TIMBER TO BE CREOSOTED.[1]

Serial Designation: D 24 - 15 T.

The specifications for this material are issued under the fixed designation D 24; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915.

General Requirements. 1. The specifications as to strength shall agree with the requirements that will be finally adopted by the Society under the Standard Definitions of Terms Relating to Structural Timber (Serial Designation: D 9);[2] that is, number of rings per inch or some substitute therefor.

(Included in this section will also be a list of the allowable defects, etc.)

Sapwood. 2. All pieces shall show at least 30 per cent sapwood in cross-section. This is based on a minimum treatment of 12 lb. of creosote per cubic foot of timber.

Bridge Stringers. 3. In bridge stringers knots greater than 1½ in. in diameter shall be at least 4 in. from the edges of the stick. There shall be no knots more than 4 in. in greatest diameter in any part of the stick.

Caps and Sills. 4. Caps, sills, posts and sawed poles shall be free from knots more than 2½ in. in diameter.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

[2] See 1916 Book of A.S.T.M. Standards, p. 598.

5. Longitudinal bracing, cross-arms and similar pieces having small cross-section shall have no knots more than 1 in. in diameter. **Bracing.**

6. Track ties shall show at least 20 per cent sapwood in cross-section. This is based on a minimum full-cell treatment of 8 lb. of creosote per cubic foot of timber. **Track Ties.**

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TENTATIVE SPECIFICATIONS
FOR
SOUTHERN YELLOW-PINE PILES AND POLES TO BE CREOSOTED.[1]

Serial Designation: D 25 - 15 T.

The specifications for this material are issued under the fixed designation D 25; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915.

General Requirements. 1. The specifications as to strength shall agree with the requirements that will be finally adopted by the Society under the Standard Definitions of Terms Relating to Structural Timber (Serial Designation: D 9);[2] that is, number of rings per inch or some substitute therefor.

(Included in this section will also be a list of the allowable defects, etc.)

Sapwood. 2. All piles or telegraph poles shall show 40 per cent sapwood in cross-section, or there shall be a ring of sapwood not less than 1 in. in thickness all around the heartwood.

Quality. 3. (*a*) Piles and poles shall be cut from sound live trees, of straight grain and regular taper; without crooks exceeding one-fourth the diameter of the stick at middle of crook when peeled. They shall be free from rot, red heart, holes or rotten knots, shakes and felling checks.

(*b*) All piles and poles shall have the bark and inner skin carefully removed when the tree is felled; all limbs and knots trimmed flush and butts cut square.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

[2] See 1916 Book of A.S.T.M. Standards, p. 598.

Minimum Diameter.

4. The minimum diameter of piles after peeling shall be as follows:

LENGTH.	BUTTS, IN.	TOPS, IN.
36 ft. and under	14	10
38 ft. and under 50 ft	14	9
50 ft. and over	15	9

No pile with butt diameter over 18 in., nor top diameter over 13½ in., will be accepted. The length of each pile is to be legibly marked on the butt with white or black paint.

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TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 40 – 17 T.

The specifications for this material are issued under the fixed designation D 40; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These specifications cover asphalt for use in damp-proofing and waterproofing, designated as type A, recommended for use under uniformly moderate temperature conditions.

I. PROPERTIES.

Melting Point. 2. The melting point shall be between 38 and 60° C. (100 and 140° F.) as determined by the ring-and-ball method in water bath, and shall be specified for one of the following classes: 54.5 to 60° C. (130 – 140° F.); 46 to 54°.5 C. (115 – 130° F.); 38 to 46° C. (100 – 115° F.). The Tentative Method for Determination of Softening Point of Bituminous Materials other than Tar Products (D 36–16 T)[2] of the American Society for Testing Materials shall be used.

Penetration. 3. The penetration at 25° C. (77° F.) under load of 100 g.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

[2] See p. 811.

for 5 seconds, as determined by the Standard Test for Penetration of Bituminous Materials (D 5-16)[1] of the American Society for Testing Materials, shall be not less than 50 nor more than 125.

The penetration shall bear the following relation to the melting point:

Penetration of 50 to 75 for melting points between 54.5 and 60° C. (130 and 140° F.).
Penetration of 75 to 100 for melting points between 46 and 54°.5 C. (115 and 130° F.).
Penetration of 100 to 125 for melting points between 38 and 46° C. (100 and 115° F.).

Ductility. 4. The ductility[2] at 25° C. (77° F.), when a briquette of the material having a minimum cross-section of 1 sq. cm. is pulled apart at the rate of 5 cm. per minute, shall not be less that 30 cm.

Specific Gravity. 5. The specific gravity shall not be more than 1.08 at 25/25° C. (77/77° F.).

Soluble in Carbon Bisulfide. 6. The bitumen soluble in cold carbon bisulfide, as determined by the method in Section 10, shall not be less than 95 per cent.

Loss on Heating. 7. The loss of a 50-g. sample on heating at 163° C. (325° F.) for 5 hours, as determined by the Standard Test for Loss on Heating of Oil and Asphaltic Compounds (D 6-16)[3] of the American Society for Testing Materials, shall not exceed 1 per cent. The penetration of the residue from this test shall be not less than 50 per cent of the original penetration specified in Section 3.

Ash. 8 The ash, as determined by the method in Section 10, shall not exceed 4 per cent.

II. METHODS OF TESTING.

9. *Specific Gravity.*—The specific gravity may be determined by any approved method, but some method similar to the following is recommended:

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[1] 1916 Book of A.S.T.M. Standards, p. 530.

[2] A detailed description of the mold and method to be followed is given in Appendix IV, Report of Committee D-4 on Road Materials, *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 349 (1915).

[3] 1916 Book of A.S.T.M. Standards, p. 533.

Weigh accurately in air a small platinum pan or crucible supported in a wire sling and suspended by a fine platinum wire or silk thread; record the weight as weight A. Then weigh it in a like manner completely immersed in freshly distilled water at 25° C. (77° F.) except for the fine platinum wire or silk thread. Record this weight as weight B. Then bring the crucible to red heat, cool and almost fill with asphalt which has been melted at the lowest possible temperature. Cool the crucible and contents to room temperature, place in the sling and weigh in air. Record the weight as weight C. Then weigh crucible and contents at 25° C. (77° F.) suspended as before in water, and record this weight as weight D. From these four weights the specific gravity may be calculated from the following formula:

$$\text{Specific Gravity} = \frac{C-A}{(C-A)-(D-B)}.$$

10. *Bitumen Soluble in Cold Carbon Bisulfide; Ash.*—For this test weigh accurately 1 to 2 g. of asphalt into an Erlenmeyer flask. Pour 100 cc. of c. p. carbon bisulfide into the flask in small portions, with continual agitation, until all lumps disappear and nothing adheres to the bottom. Cork the flask and set aside for 15 minutes. Then filter the solution by suction through an asbestos pad in a Gooch crucible (the best size of crucible for this test is 4.4 cm. wide at the tod tapering to 3.6 cm. at the bottom, and 2.5 cm. deep), which has been previously prepared and weighed. Care shall be exercised in decanting the liquid portion. Stop the decantation at the first sign of sediment coming out. Wash the sides of the flask with a small amount of fresh carbon bisulfide and bring the sediment upon the felt, using a "policeman," if necessary, to remove all adhering material. Then wash the material on the mat with carbon bisulfide until the washings are colorless and continue suction until the odor of carbon bisulfide is hardly detectable. Then clean the outside of the crucible with a cloth moistened with a small amount of solvent. Dry the crucible with contents for one-half hour at 105° C. (221° F.), cool in a desiccator and weigh.

The total weight of insoluble material includes both organic and inorganic insoluble. If organic insoluble material is present, heat the crucible to red heat until no carbonaceous particles remain,—leaving only the mineral ash,—cool and weigh. The percentage soluble in carbon bisulfide, the organic insoluble, if there is any present, and the ash should total 100 per cent. Each should be reported.

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TENTATIVE SPECIFICATIONS
FOR
PRIMER FOR USE WITH ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 41 – 17 T.

The specifications for this material are issued under the fixed designation D 41; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These specifications cover primer for use, when specified, with asphalt for use in damp-proofing and waterproofing.

Primer. 2. The primer shall consist of an asphaltic base, complying in every respect with the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing (Type A)[2] for use below grade, which shall be thinned to ordinary paint consistency with a petroleum distillate having an end point on distillation not above 260° C. (500° F.). Not more than 20 per cent of this petroleum distillate shall distill under 120° C. (248° F.).

The distillation shall be carried out according to the Standard Tests for Paint Thinners other than Turpentine (D 28–17)[3] of the American Society for Testing Materials.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

[2] See p. 712.

[3] See "A.S.T.M. Standards adopted in 1917," p. 7.

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TENTATIVE SPECIFICATIONS
FOR
COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 42 – 17 T.

The specifications for this material are issued under the fixed designation D 42; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These specifications cover coal-tar pitch for use in damp-proofing and waterproofing, designated as type A, recommended for use under uniformly moderate temperature conditions.

I. PROPERTIES.

Melting Point. 2. The melting point, as determined by the cube method in water bath, Section 9, shall be between 49 and 60° C. (120 and 140° F.). In specifying the melting point desired within the above limits, a variation of not more than 2°.5 C. (5° F.) in either direction will be permitted.

Penetration. 3. The penetration at 25° C. (77° F.) under load of 100 g. for 5 seconds, as determined by the Standard Test for Penetration of Bituminous Materials (D 6–16)[2] of the American Society for Testing Materials, shall not be less than 20 nor more than 120.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

[2] 1916 Book of A.S.T.M. Standards, p. 530.

Ductility. 4. The ductility[1] at 25° C. (77° F.). when a briquette of the material having a minimum section of 1 sq. cm. is pulled apart at the rate of 5 cm. per minute, shall not be less than 40 cm.

Loss on Heating. 5. The loss of a 20-g. sample on heating at 163° C. (325° F.) for 5 hours, as determined by the Standard Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 – 16)[2] of the American Society for Testing Materials, on pitch of melting point between 49 and 54°.5 C. (120 and 130° F.) shall not exceed 9 per cent and on pitch of melting point between 54.5 and 60° C. (130 and 140° F.) shall not exceed 7 per cent.

Specific Gravity. 6. The specific gravity of the pitch at 25/25° C. (77/77° F.) shall not exceed the limits 1.24 and 1.34.

The specific gravity at 60/60° C. (140/140° F.) of the distillate to 355° C. (671° F.) shall not be less than 1.06.

Soluble Matter. 7. The matter soluble in hot toluol-benzol, as determined by the method in Section 12, shall not be less than 65 nor more than 85 per cent.

Ash. 8. The ash, as determined by the method in Section 13, shall not exceed 1 per cent.

II. METHODS OF TESTING.

9. *Melting Point.*—The melting point shall be the temperature at which the pitch formed in a ½-in. cube and suspended in a vessel of water 1 in. above the bottom shall touch the bottom of this vessel. The cube is formed by pressing the pitch in a suitable mold. Remove the cube from the mold and suspend on the lower arm of a No. 12 B. & S. gage wire bent at right angles. The wire should be passed through the center of two opposite faces of the cube. Immerse the cube in 400 cc. of freshly boiled distilled water at a temperature of 15°.5 C. (60° F.) contained in a 600-cc. beaker. Maintain this temperature until the pitch is the same temperature as the water. Apply heat in such a manner that the temperature of the water is raised 5° C. (9° F.) per minute, until the pitch touches the bottom of the beaker. At this point the temperature, recorded

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[1] A detailed description of the mold and method to be followed is given in Appendix IV, Report of Committee D-4 on Road Materials, *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 349 (1915).

[2] 1916 Book of A.S.T.M. Standards, p. 533; use a 20-g. sample instead of the 50-g. sample specified.

by a thermometer whose bulb shall be level with the cube, shall be considered as the melting point of the pitch.

10. *Specific Gravity.*—The specific gravity may be determined by any approved method, but some method similar to the following is recommended:

Weigh accurately in air a small platinum pan or crucible supported in a wire sling and suspended by a fine platinum wire or silk thread; record the weight as weight A. Then weigh it in a like manner completely immersed in freshly distilled water at 25° C. (77° F.), except for the fine platinum wire or silk thread. Record this weight as weight B. Then bring the crucible to red heat, cool and almost fill with pitch which has been melted at the lowest possible temperature. Cool the crucible and contents to room temperature, place in the sling and weigh in air. Record the weight as weight C. Then weigh crucible and contents at 25° C. (77° F.) suspended as before in water, and record this weight as weight D. From these four weights the specific gravity may be calculated from the following formula:

$$\text{Specific Gravity} = \frac{C-A}{(C-A)-(D-B)}.$$

11. *Specific Gravity of Distillate.*—Distill in a glass or metal retort, preferably of 8-oz. capacity, at least 100 g. of the pitch to 355° C. (671° F.) vapor temperature, catching the distillate. The specific gravity may be determined by any approved method, but the following is recommended:

Clean a 10-cc. specific-gravity bottle; dry and weigh. Fill it with distilled water and heat to 60° C. (140° F.) as described below; dry and weigh. Then fill the bottle with distillate, immerse in water and heat slowly to 60° C. (140° F.), maintaining this temperature for at least 5 minutes. Dry, cool and weigh. From these weights the specific gravity may be determined from the following formula:

$$\text{Specific Gravity} = \frac{\text{Weight of bottle} + \text{distillate} - \text{weight of bottle}}{\text{Weight of bottle} + \text{water} - \text{weight of bottle}}.$$

12. *Matter Insoluble in Hot Toluol-Benzol Extraction.*[1]—In

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[1] A full description of a simple apparatus for this test may be found in the *Journal of Industrial and Engineering Chemistry*, Vol. 6, pp. 279–285.

testing materials of 5 per cent or more insoluble matter 5 g. should be taken for the test. With lesser percentages 10 g. should be used. Weigh out the amount in a 100-cc. beaker, and digest with about 50 cc. of c. p. toluol on the steam bath, for a period not to exceed 30 minutes. If the solution is kept hot and constantly stirred, the digestion can be completed very rapidly. Weigh a filter cup, previously prepared, in a weighing bottle and place in a carbon filter tube over a beaker or flask. Decant the toluol-tar mixture through the thimble and wash with hot c. p. toluol until clean, using some form of "policeman" which is unaffected by toluol, for the purpose of detaching any residue which may adhere to the beaker. Finally, wash the cup with hot c. p. benzol and then, after draining, cover with a cap of filter paper or alundum, and place in the extraction apparatus in which the c. p. benzol is used as solvent. Continue the extraction until the descending benzol is colorless. Remove the thimble, take off the cap, dry in the steam oven and weigh in the weighing bottle after cooling in the desiccator. The balance used for this work should be accurate to at least ½ mg. It is well to examine the insoluble residue for foreign matter such as wood, slivers, pieces of bagging, etc. If such foreign matter is present, the test should be rejected.

13. *Ash.*—This determination is made by burning to ash a 1-g. sample of the material in a weighed platinum crucible or dish of sufficient size. Apply heat gently until the pitch ignites, then withdraw the heat. After the pitch ceases to burn, apply the heat again until the residue is burned free of carbon. Then cool the crucible and contents, weigh, and determine the ash.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS FOR CREOSOTE OIL FOR PRIMING COAT WITH COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 43 – 17 T.

The specifications for this material are issued under the fixed designation D 43; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. When it is specified that previous to the mopping on of the hot coal-tar pitch, the wall, floor, or foundation shall be painted with a priming coat, the following specifications for creosote oil shall apply:

Definition. 2. Creosote oil shall be a pure tar distillate free from any substance foreign to a tar distillate.

Melting Point. 3. The oil shall be entirely fluid at 38° C. (100° F.).

Specific Gravity 4. The specific gravity at 38° C. (100° F.) shall not be less than 1.00 nor more than 1.06.

Insoluble Matter. 5. Insoluble matter in hot benzol shall be less than 1 per cent.

Distillation. 6. When distilled in accordance with the Standard Methods for Sampling and Analysis of Creosote Oil (D 38–17)[1] of the American Society for Testing Materials, it shall yield:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Interocean Oil Co., East Brooklyn, Baltimore, Md.

(*a*) Water, not more than 2 per cent.

(*b*) Not more than 5 per cent shall distill under 200° C. (392° F.).

(*c*) Not more than 50 nor less than 30 per cent shall distill under 235° C. (455° F.).

(*d*) The residue above 355° C. (671° F.) shall not exceed 15 per cent.

(*e*) The residue shall be soft.

(*f*) The specific gravity at 38° C. (100° F.) of the fraction distilling between 235 and 315° C. (455 and 599° F.) shall not be less than 1.00.

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[1] See "A.S.T.M. Standards adopted in 1917," p. 30.

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TENTATIVE SPECIFICATIONS
FOR
CANNED FOODS BOXES, NAILED AND LOCK-CORNER CONSTRUCTION.[1]

Serial Designation: D 44 – 17 T.

The specifications for this material are issued under the fixed designation D 44; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Manufacture. 1. Boxes shall be well manufactured from sound (free from decay or dote), well-seasoned lumber. Boxes when stored after nailing should not be placed in a heated room. Lumber shall be free from knot holes, loose or rotten knots greater than 1 in. in diameter. No knots will be permitted which will interfere with the proper nailing of the box.

Cleating. 2 Cleats shall be $1\frac{1}{8}$ by $\frac{3}{8}$ in., or any other size that has equally large cross section, with six nails to each cleat driven through and clinched. No piece of end shall have less than two nails. The outside nails shall be driven as near the ends of cleats as possible without splitting the cleat; the remainder of the nails shall be as evenly spaced as possible. No nail shall be driven in a joint.

Nailing. 3. Nails shall be as evenly spaced as possible, and no nail shall be driven in a joint. All nails shall be driven squarely into the center of the thickness of the end. There shall be at least two nails in each end of any one piece of lumber.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Col. B. W. Dunn, Chairman of Committee D-10 on Shipping Containers, 120 Broadway, New York City.

Outside nails on the sides shall be driven just inside the end nails of the cleats.

Outside nails on the top and bottom shall be driven far enough inside to miss the side nails.

The sides, tops and bottoms shall be flush with the ends.

The tops and bottoms shall overlap the sides.

The size of nails shall depend on the woods used for the ends.

II. DIVISION BY SPECIES OF WOOD.

(*A*) *Group I.*[1]

Group I.

4. Group I shall comprise the following species of wood:

White pine
Aspen
Western yellow pine
Spruce
Cottonwood
Yellow poplar
Balsam fir
Chestnut
Sugar pine
Basswood
Cypress
Willow
Noble fir
Magnolia
Buckeye
White fir
Cedar
Redwood
Butternut
Cucumber
Alpine fir
Lodgepole pine

Nos. 2½ and 3 Cans, Group I.

5. Boxes for two dozen No. $2\frac{1}{2}$, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick, and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used the third corrugated fastener may be omitted.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

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[1] When one-piece sides and two-piece tops and bottoms of sawed lumber are used, material $\frac{1}{32}$ in. thinner will be permitted. The thicknesses specified herein are to allow for an occasional unavoidable variation in manufacture, but that variation shall not exceed $\frac{1}{64}$ in. below the thicknesses specified.

There shall be seven *6d* standard, cement-coated box nails, not less than $1\frac{13}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{5}{8}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued. The top and bottom shall be nailed with not less than fourteen *6d* standard, cement-coated box nails in each top and each bottom.

Nos. 1 and 2 Cans, Group I.

6. Boxes for two dozen No. 1, four dozen No 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be seven *6d* standard, cement-coated box nails, not less than $1\frac{13}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{5}{8}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued. The top and bottom shall be nailed with not less than fourteen *6d* standard, cement-coated box nails in each top and each bottom.

Nos. 1 and 2 Cans, Group I.

7. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick, and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be six *6d* standard, cement-coated box nails, not less than $1\frac{13}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends and sides shall be at least $\frac{7}{16}$ in. thick, and the top and bottom $\frac{5}{16}$ in. thick; or $\frac{1}{2}$-in. ends may be used with $\frac{5}{16}$-in. sides, top and bottom. All piecing shall be tongued, grooved and glued, and the top and bottom shall be nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

(*B*) *Group II.*[1]

Group II.

8. Group II shall comprise the following species of wood:

Southern yellow pine
Hemlock
Virginia and Carolina pine
Douglas fir
Larch

Nos. 2½ and 3 Cans, Group II.

9. Boxes for two dozen No. $2\frac{1}{2}$, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used, the third corrugated fastener may be omitted.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be seven 5*d* standard cement-coated, box nails, not less than $1\frac{9}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{5}{8}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued, and nailed with not less than fourteen 5*d* standard, cement-coated box nails in each top and each bottom.

Nos. 1 and 2 Cans, Group II.

10. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{5}{8}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

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[1] When one-piece sides and two-piece tops and bottoms of sawed lumber are used, material $\frac{1}{32}$ in. thinner will be permitted. The thicknesses specified herein are to allow for an occasional unavoidable variation in manufacture, but that variation shall not exceed $\frac{1}{32}$ in. below the thicknesses specified.

There shall be six 5*d* standard, cement-coated box nails, not less than $1\frac{9}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends and sides shall be at least $\frac{7}{16}$-in. thick and the top and bottom $\frac{5}{16}$ in. thick; or $\frac{1}{2}$-in. ends may be used with $\frac{5}{16}$-in. sides, top and bottom. All piecing shall be tongued, grooved and glued and the top and bottom nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

(*C*) *Group III.*[1]

Group III.

11. Group III shall comprise the following species of wood:

White elm
Red gum
Sycamore
Pumpkin ash
Black ash
Black gum
Tupelo
Maple, soft or silver

Nos. 2½ and 3 Cans, Group III.

12. Boxes for two dozen No. $2\frac{1}{2}$, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{1}{2}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used, the third corrugated fastener may be omitted.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

A veneer of Red gum $\frac{1}{4}$ in. thick shall be used with one-piece sides and tops, and one and two-piece bottoms. No piece shall be less than 2 in. in width.

There shall be seven 4*d* standard, cement-coated box nails, not less than $1\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{1}{2}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued, and the top and bottom nailed with not less than fourteen 4*d* standard, cement-coated box nails in each top and each bottom.

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[1] When one-piece sides and two-piece tops and bottoms of sawed lumber are used, material $\frac{1}{32}$ in. thinner will be permitted. The thicknesses specified herein are to allow for an occasional unavoidable variation in manufacture, but that variation shall not exceed $\frac{1}{64}$ in. below the thicknesses specified.

Nos. 1 and 2 Cans, Group III.

13. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{1}{2}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{5}{16}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

A veneer of Red gum $\frac{1}{4}$ in. thick shall be used with one-piece sides and tops, and one and two-piece bottoms. No piece shall be less than 2 in. in width.

There shall be six 4*d* standard, cement-coated box nails, not less than $1\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{1}{2}$ in. thick, and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued and the top and bottom shall be nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

(*D*) *Group IV.*

Group IV.

14. Group IV shall comprise the following species of wood:

Hard maple
Beech
Oak
Hackberry
Birch
Rock elm
White ash

Nos. 2½ and 3 Cans, Group IV.

15. Boxes for two dozen No. $2\frac{1}{2}$, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{1}{2}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with three 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain. When one-piece sides are used, the third corrugated fastener may be omitted.

The sides, tops and bottoms shall be of sawed lumber

$\frac{1}{4}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be seven 4*d* standard, cement-coated box nails, not less than $1\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{1}{2}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued, and the top and bottom nailed with not less than fourteen 4*d* standard, cement-coated box nails in each top and each bottom.

Nos. 1 and 2 Cans, Group IV.

16. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) *Nailed Construction.*—The ends shall be $\frac{1}{2}$ in. thick and of one or two pieces. Two-piece ends shall be cleated or fastened with two 1 by $\frac{3}{8}$ in. corrugated steel fasteners, driven transversely with the grain.

The sides, tops and bottoms shall be of sawed lumber $\frac{1}{4}$ in. thick, not more than two pieces to each side or three pieces to each top or bottom. No piece shall be less than 2 in. in width.

There shall be six 4*d* standard, cement-coated box nails, not less than $1\frac{5}{16}$ in. in length, to each nailing edge.

(*b*) *Lock-Corner Construction.*—The ends shall be $\frac{1}{2}$ in. thick and the sides, top and bottom $\frac{5}{16}$ in. thick. All piecing shall be tongued, grooved and glued and the top and bottom nailed with not less than twelve 4*d* standard, cement-coated box nails in each top and each bottom.

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TENTATIVE SPECIFICATIONS

FOR

CANNED FOODS BOXES, WIREBOUND CONSTRUCTION.[1]

Serial Designation: D 45 – 17 T.

The specifications for this material are issued under the fixed designation D 45; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Manufacture.

1. Boxes shall be well manufactured from sound (free from decay or dote), well-seasoned veneer and cleat lumber. Kiln drying by excessively high temperatures or low humidities or below 6 per cent moisture shall be avoided. Veneer shall be free from knot holes, loose or rotten knots greater than 1 in. in diameter. Cleats shall be free from knots and from excessive cross grain. No knots will be permitted which will interfere with proper nailing or stapling. Each side, top, and end shall be of a single piece of veneer; the bottoms shall consist of not more than two pieces, no piece less than 4 in. in width.

Nos. $2\frac{1}{2}$ and 3 Cans.

2. Boxes for two dozen No. $2\frac{1}{2}$, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Cleats*.—Each end shall be cleated with four cleats not less than $\frac{15}{16}$ by $\frac{11}{16}$ in., or any other size cleats that have equally large cross section. One end of each cleat shall be provided with a tenon $\frac{1}{4}$ in. thick and $\frac{15}{16}$ in. long and the other end with the corresponding mortise. Cleats may be made of any of the following species of wood:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Col. B. W. Dunn, Chairman of Committee D-10 on Shipping Containers, 120 Broadway, New York City.

Red gum
Black gum
Maple
Birch
Beech
Tupelo
Elm
Oak
Sycamore
Ash
Hickory
Hackberry
Yellow pine

(*b*) The sides, top, bottom and ends shall be of $\frac{1}{8}$-in. gum[1] veneer. The box shall be bound with four equally spaced 16-gage 0.0625-in. diameter, basic annealed wires. End wires shall be attached to cleats with 16-gage by $1\frac{1}{8}$-in. bright, soft Bessemer staples driven through the veneer into the center of the width of the cleats. Six staples shall be driven into each top and bottom cleat and four into each side cleat. Interior wires shall be attached to the veneer by 18-gage, bright, soft Bessemer staples driven through and clinched; six staples connecting each wire to top and bottom and four to each side.

(*c*) The ends shall be attached to each side cleat by four 18-gage by $\frac{13}{16}$-in. staples equally spaced, driven into the center of the cleat and at an angle of 45 to 60 deg. with the grain of the end; or by four nails $\frac{7}{8}$-in. by 15-gage by $\frac{1}{4}$-in. head, driven into the center of the cleat and equally spaced.

Nos. 1 and 2 Cans.

3. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

(*a*) These boxes shall be the same as those for No. 3 cans, except that wires shall be stapled to the tops and bottoms with four staples to each wire and to the sides with three staples to each wire.

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[1] Specifications for boxes of other kinds of veneer and with cleats of other species than those listed have been withheld pending tests.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS

FOR

2½, 3 AND 3½-IN. DOUBLE-JACKETED COTTON RUBBER-LINED FIRE HOSE FOR PUBLIC FIRE DEPARTMENT USE.[1]

Serial Designation: D 26 - 16 T.

The specifications for this material are issued under the fixed designation D 26; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

I. COTTON FABRIC.

Quality of Cotton Fabric.

1. (*a*) The cotton fabric shall be even and firm in texture throughout and free from all injurious or unsightly defects, except such trifling ones as are incident to the best manufacturing practice. The filling threads (or weft) shall be thoroughly covered by the warp in woven fabric, while in knit fabric both warp and filling shall be covered by the knitted loop.

(*b*) The cotton cover shall consist of two plies, separate or interwoven.

II. RUBBER LINING.

Quality of Rubber Lining.

2. (*a*) The rubber lining shall be of uniform quality, free from defects, and as free from corrugations as may be possible with the best methods of manufacture.

(*b*) It shall contain, exclusive of cement and backing, not less than 40 per cent by weight, as found by analysis, of pure fine Para rubber or its equivalent, and shall not contain any kind of rubber substitutes, old vulcanized, or reclaimed rubber.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. E. A. Barrier, Chairman of Committee D-11 on Rubber Products, 31 Milk St., Boston, Mass.

(*c*) It shall be cemented to the cotton fabric with cement which will meet requirements of Section 3 (*g*).

(*d*) It shall be lap-jointed, and the lap shall be as small and as neat as is consistent with the best results.

(*e*) The lining (without cement and backing) shall be made up of not less than three calendered sheets, and shall be not less than 0.058 in. in thickness, and, including cement and other backing, shall not exceed 0.090 in. in thickness.

Tests of Rubber Lining.

3. (*a*) The tensile strength shall be not less than 1600 lb. per sq. in.

(*b*) The length at time of breaking shall be not less than six times the initial length.

(*c*) Mark two lines on the test specimen 2 in. apart and at right angles to the direction of pull. Stretch to 10 in. and hold in that position for 10 minutes. Ten minutes after release, the distance between the two lines shall not exceed 2.4 in.

(*d*) The compound used shall not contain more than 7.5 per cent of sulfur, exclusive of that which may be contained in the mineral matter, as barytes, and the free sulfur shall not exceed 3 per cent; both figures shall be based upon the amount of gum as found by chemical analysis.

(*e*) The organic-acetone extract shall not exceed 5 per cent of the gum as found by chemical analysis.

(*f*) The saponifiable matter extracted by alcoholic potash after the acetone extraction has been made shall not exceed 2 per cent of the gum as found by chemical analysis.

(*g*) The adhesion, or "friction," between the cement backing and the cotton fabric, shall be such that when a 9-lb. weight is suspended from the free end of a 1-in. strip of the lining cut circumferentially from the hose, the lining shall not separate from the backing or fabric at a rate greater than 1 in. per minute.

III. HOSE.

Diameter of Hose.

4. The internal diameter of the hose shall be not less than the size called for in the schedule, namely 2½, 3 or 3½ in.

Weight and Flexibility of Hose. 5. (*a*) The weight of the finished hose per 50-ft. length without couplings shall be not more than the following amounts:

SIZE OF HOSE, IN.	MAX. WEIGHT PER 50-FT. LENGTH, LB.
2½	70
3	90
3½	110

(*b*) The hose shall be flexible and easily coiled.

Strength of Hose. 6. (*a*) The hose shall meet the following requirements for minimum bursting pressure. Tests on 50-ft. lengths need not be made unless specified by the purchaser.

WHEN LYING STRAIGHT.

Length of sample, ft	3	50
Bursting pressure, min., lb. per sq. in	600	500

WHEN BENT IN A CURVE THE RADIUS OF WHICH IS 2½ FT.

Length of sample, ft	3	50
Bursting pressure, min., lb. per sq. in	600	500

WITH ENDS TIED TOGETHER AND COUPLINGS TOUCHING, AND WITH A SHARP KINK IN THE MIDDLE.

Bursting pressure, min., lb. per sq. in	350

(*b*) Every length of hose shall be tested by the manufacturer after coupling but before delivery, with 400 lb. pressure. It shall be carefully dried before shipment.

Elongation of Hose. 7. The elongation between 10 and 100 lb. shall not exceed 3 per cent and between 10 and 400 lb. 8 per cent of the original length, as measured at 10 lb. pressure.

Distortion of Hose. 8. The hose shall not twist more than 12 deg. per foot at 400 lb. pressure. The twist shall be in such direction as to tighten rather than loosen the couplings.

Marking of Hose. 9. Each 50-ft. length of hose shall be stenciled twice in black letters 1 in. high, beginning not more than 4 ft. from the couplings, as follows: "A. S. T. M. Specifications," also with the name of the manufacturer, the month and year of manufacture, and the words "tested to 400 lb."

Couplings. 10. (*a*) Couplings shall be made, finished and fitted in a workmanlike manner throughout. The diameter through couplings shall be according to the size of the hose, namely, 2½, 3, or 3½ in.

(*b*) They shall be of the expansion-ring pattern, of ample strength, and of the best form to resist the strain of expanding the binding ring in the coupling. They shall have a tail part sufficiently long to extend $\frac{1}{8}$ in. beyond the end of the expansion ring. They shall be fitted with expansion rings having the following lengths and gaskets of the following thickness:

SIZE OF HOSE, IN.	LENGTH OF EXPANSION RINGS, IN.	THICKNESS OF GASKETS, IN.
$2\frac{1}{2}$	$1\frac{1}{2}$	$\frac{3}{16}$
3	$1\frac{3}{4}$	$\frac{1}{4}$
$3\frac{1}{2}$	$2\frac{1}{2}$	$\frac{1}{4}$

(*c*) They shall be made of an alloy of copper, tin and zinc (and lead if desired) of the following proportions:

Copper	not under	82	per cent.
Tin	" "	5	"
Zinc	" over	7	"
Lead	" "	3	"

Couplings, including both male and female and expansion rings, shall weigh not less than the following amounts:

SIZE OF HOSE, IN.	MINIMUM WEIGHT PER SET OF COUPLINGS, LB.
$2\frac{1}{2}$	$5\frac{3}{4}$
3	8
$3\frac{1}{2}$	$12\frac{1}{2}$

Both male and female shall be stamped with the name of the manufacturer of the couplings and the month and year of manufacture in letters and figures not less than $\frac{1}{8}$ in. high.

(*d*) They shall be provided with rubber gaskets of the same quality as the rubber lining, and accurately fitted.

(*e*) They shall have on the couplings, inside each expansion ring, a rubber washer at least $\frac{3}{16}$ in. in thickness and with inside diameter not less than that of the coupling. Hose coupling threads shall be interchangeable with those now in use in the city or town, but wherever practicable an effort should be made to introduce the "National Standard" thread adopted in 1906 by the National Fire Protection Association.

The essential features of the "National Standard" are a

60-deg. V-thread, and the following more important features for the different sizes:

SIZE OF COUPLINGS, IN.	NUMBER OF THREADS PER INCH.	OUTSIDE DIAMETER OF MALE THREADS IN.
2½	7½	3 1/16
3	6	3⅝
3½	6	4¼

NOTES.

In many cases where the number of threads and the outside diameters of the male ends do not differ greatly from the Standard, it is possible to render both male and female couplings adaptable for interchange with the Standard by the use of an adjustable tap for the female end or an adjustable die for the male end of the coupling. This tap or die should have the same number of threads per inch as the coupling or nipple to be treated.

In cases where the above change in the existing equipment cannot be made, the hydrant nipples can be equipped with adapters provided with spanner lugs and having a Standard male thread on the out-board end.

Two and one-half inches is specified above as the diameter for the smaller hose since this size is standard throughout the country for Public Fire Department use. It is recommended however that an effort be made to introduce the use of 2⅝-in. hose, which has practically replaced the 2½-in. hose for private department use for many years. The 2⅝-in. hose has about 20 per cent less friction loss than the 2½-in. hose and can be used without difficulty on the present equipment of couplings and playpipes. When 2⅝-in. hose is used the specifications for 2½-in. hose should apply with the exception of weight, in which case the maximum weight should be 75 lb. per 50-ft. length.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: 30 PER CENT HEVEA RUBBER.[1]

Serial Designation: D 27 – 16 T.

The specifications for this material are issued under the fixed designation D 27; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Scope. 1. These specifications cover conductors and rubber insulation only. The design and factor of safety depend upon the service conditions and shall be at the option of the purchaser.

(*A*) *Conductor.*

I. MANUFACTURE.

Material. 2. The conductor shall be made of soft annealed copper, properly tinned, and have the properties and characteristics herein required.

Strand. 3. Each individual wire of a stranded conductor shall be considered separately and shall be designated as a strand.

Shape. 4. Each solid conductor and each strand shall be round and reasonably free from imperfections.

Stranding. 5. The stranding shall be concentric, unless otherwise specified, and shall conform to Table I.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. E. A. Barrier, Chairman of Committee D-11 on Rubber Products, 31 Milk Street, Boston, Mass.

Density. 6. For the purpose of calculating weights, cross-sections, etc., in conductivity determinations, the density of the copper shall be taken as 8.89. See Appendix I.

TABLE I.—STRANDING.

(ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Sizes.	Minimum Number of Strands in Conductor.
2 000 000 to 1 600 000 C. M	127
1 500 000 " 1 100 000 "	91
1 000 000 " 550 000 "	61
*500 000 " 250 000 "	37
No. 0000 " No. 1 A. W. G. or B. & S	19
No. 2 " No. 8 " "	7
Smaller sizes	1

II. PHYSICAL PROPERTIES AND TESTS.

Tensile Properties. 7. Each solid conductor or strand shall be so drawn and annealed that after tinning it shall conform to the properties given in Table II.

TABLE II.—TENSILE PROPERTIES.

(AMERICAN SOCIETY FOR TESTING MATERIALS.)

Diameter, in.	Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent.
0.460 to 0.290	36 000	35
0.289 " 0.103	37 000	30
0.102 " 0.021	38 500	25
0.020 " 0.003	40 000	20

Tension Tests. 8. (*a*) *Method of Test.*—Tensile tests shall be made on fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks originally 10 in. apart. The specimen shall break between the bench marks and not closer than 1 in. to either mark.

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 16.

(*c*) *Retests and Rejections.*—If upon testing a sample from a coil, reel or spool of wire, the results are found to be above the stated value for tensile strength or below the stated value for elongation, tests upon two additional samples will be made and the average of the three tests shall determine acceptance or rejection.

Conductivity.

9. The conductivity of the copper shall be not less than 98 per cent of the annealed copper standard. See Appendix I.

Tinning Tests.

10. (*a*) *Test.*—Each sample before stranding or insulating shall be given the following tests at the factory: The sample shall be thoroughly cleaned by immersing in redistilled petroleum ether, followed by immersion in 95 per cent alcohol. The sample shall then be immersed in hydrochloric acid (sp. gr. 1.088) at a temperature of from 60 to 70° F. (15°.55–21°.10 C.) for one minute, washed in distilled water (the surplus water shaken off) and immersed in a solution of sodium sulfide for 30 seconds and again washed in water (the surplus water shaken off). The above operation shall be repeated four times for samples 0.02 in. in diameter or over, and three times for samples less than 0.02 in. in diameter. After the completion of the required number of cycles the samples shall not show any sign of blackening in the air which is perceptible to the eye.

(*b*) *Strength of Solution.*—The solution of sodium sulfide shall have sufficient strength to thoroughly blacken in 5 seconds a piece of untinned copper wire that has previously been cleaned in 95 per cent alcohol. The solution shall be prepared by thoroughly saturating (by boiling) a solution of sodium monosulfide with sulfur and shall have a specific gravity of 1.142 at 60° F. (15°.55 C.).

(*c*) *Number of Tests.*—Samples shall be taken in accordance with Section 16.

(*d*) *Retests and Rejections.*—If the specimen tested in accordance with Section 10 (*a*) shows any signs of blackening, two more specimens shall be tested. If one of these two additional specimens shows any signs of blackening, that coil or reel shall be rejected. If both specimens are free from any signs of blackening, the coil or reel shall be accepted. If more than

10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel or length may be tested and accepted or rejected upon the results of the individual tests.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Diameter and Area.

11. (*a*) *Permissible Variation.*—When the diameter of solid conductors and strands is specified, the permissible variation from the specified value shall not exceed 1 per cent under or 2 per cent over for wire 0.02 in. in diameter and larger, and 0.1 mil under for wire less than 0.02 in. in diameter.

When the area of cross-section is specified, the permissible variation shall not exceed 2 per cent under the specified value.

(*b*) *Method of Gaging Diameter.*—When wire is submitted in coils, each coil shall be gaged in three places, one near each end and one approximately at the middle. When wire is submitted on spools or reels, approximately 12 ft. of the wire shall be reeled off and the wire then gaged in six places between the second foot and the twelfth foot from the end.

(*c*) *Calculation of Area.*—The area of cross-section of wire shall be calculated from the average of the measurements of the diameter made in accordance with Section (*b*). The area of cross-section of cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

(*d*) *Rejection.*—A coil or reel shall be rejected if the average diameter obtained from the measurements made in accordance with paragraph (*b*), or the area as calculated in accordance with paragraph (*c*), is not within the limits specified in paragraph (*a*).

A coil or reel shall be rejected if any individual measurement of diameter or of area of cross-section is not within twice he limits specified in paragraph (*a*).

(*B*) *Insulation.*

IV. CHEMICAL PROPERTIES AND TESTS.

Composition of Compound.

12. (*a*) *Composition.*—The insulation shall contain exclusively Hevea rubber which has not been previously used, waxy hydrocarbons consisting of ceresin or refined paraffin, sufficient

sulfur to properly vulcanize, and fillers which are entirely inorganic mineral matter containing no red lead, carbon or bitumen.

(*b*) *Requirements.*—The vulcanized compound shall conform on analysis to the following requirements expressed as percentages, by weight, of the whole sample:

	MAXIMUM.	MINIMUM.
Rubber	33	30
Waxy hydrocarbons	4	..
Free sulfur	0.7	..

Results shall be taken between the limits given in proportion to the percentage by weight of the rubber found.

The limits allowed for 30-per-cent rubber compound shall be as follows:

	MAXIMUM.	MINIMUM.
Saponifiable acetone extract	1.35	0.55
Unsaponifiable resins	0.45	....
Chloroform extract	0.90	....
Alcoholic potash extract	0.55	....
Total sulfur (see note)	2.10	....
Specific gravity	....	1.75

The limits allowed for 33-per-cent rubber compound shall be as follows:

	MAXIMUM.	MINIMUM.
Saponifiable acetone extract	1.50	0.60
Unsaponifiable resins	0.50	....
Chloroform extract	1.00	....
Alcoholic potash extract	0.60	....
Total sulfur (see note)	2.30	....
Specific gravity	....	1.67

The acetone solution shall not fluoresce.

The acetone extract (60 cc.) shall not be darker than a light straw color.

Hydrocarbons shall be solid, waxy and not darker than a light brown.

Chloroform extract (60 cc.) shall not be darker than a straw color.

Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to this specification.

NOTE.—The limit on total sulfur may be omitted at the option of the purchaser.

The compound shall be analyzed by the procedure recommended by the Joint Rubber Insulation Committee. See Appendix II.

(*c*) *Samples.*—Samples for chemical analysis shall be taken before the application of the braid and after the material has passed all physical and electrical tests. The purchaser may take samples in accordance with Section 16. The purchaser shall assure himself that all samples are free from contamination and change due to torch heating. Wherever practicable, samples shall be taken at a distance of at least 3 ft. from the end of the wire.

(*d*) *Retests and Rejections.*—The purchaser may make a chemical analysis on any one of the samples selected as above to determine if the compound meets the requirements of Section 12 (*b*). Failure of any one sample selected shall be sufficient cause to reject the wire which the sample represents, except in the case of failure to meet the requirements of either or both free sulfur and chloroform extract in accordance with Section 12 (*b*). In case of such failure the coil from which the sample was taken shall be rejected and two additional samples taken from the remainder of the order. The remainder of the order shall be accepted if both samples so selected shall meet the requirements for free sulfur or chloroform extract in accordance with Section 12 (*b*). The entire order shall be rejected if either sample fails to meet the requirements.

V. PHYSICAL PROPERTIES AND TESTS.

Physical Properties.

13. The test specimen shall have the following physical properties.

Tensile strength, minimum, lb. per sq. in.	1000
Set, maximum in 2 in., in.	$\frac{3}{8}$
Elongation, minimum before rupture, in.	2 to 9

Physical Tests.

14. (*a*) *Tension Test.*—A test specimen having a length of not less than 2 in., marked with bench marks 2 in. apart, shall be placed in the jaws of a test machine (maximum distance

between jaws holding the test specimen, 4 in.) and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the bench marks and the tensile strength shall be calculated upon the area of the original sample.

(*b*) *Set Test.*—A second test specimen having a length of not less than 6 in., marked with bench marks 2 in. apart, shall be placed in the jaws of a test machine (maximum distance between jaws holding test specimen, 4 in.) and stretched at a rate of 20 in. per minute until the bench marks are 6 in. apart. After the termination of this stretch, the test specimen shall be released within 5 seconds and the set determined 1 minute after the beginning of release.

(*c*) *Elongation Test.*—After the determination of the set in accordance with paragraph (*b*), the *same* specimen shall be placed in the jaws of a test machine (maximum distance between jaws holding test specimen, 4 in.) and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the bench marks.

(*d*) *Accuracy of Machine.*—The test machine shall be accurate within 1 per cent of the breaking load.

(*e*) *Jaws.*—The jaws of the machine shall be of an approved type.

(*f*) *Temperature.*—All physical tests shall be made at a room temperature of from 65 to 85° F. (18°.33 to 29°.44 C.) inclusive, and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the tests.

Test Specimen.

15. (*a*) *Test Specimen.*—The test specimen may be the entire section of the insulation in the case of small wires, or in the case of a large wire, a segment of a section, cut with a sharp knife held tangentially to the conductor. The test specimen shall be as free as possible from surface incisions and imperfections.

(*b*) *Buffing.*—In event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

(*c*) *Limits.*—There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the test machine.

(*d*) *Calculation of Area.*—Calculation of the area of test specimen shall be made as follows:

(1) When the total cross-section of the insulation is used, the area shall be calculated as the area of the circle whose diameter is the minimum average outside diameter of the insulation minus the area of the conductor. The area of a stranded conductor shall be figured from its maximum diameter.

(2) When a slice cut from the wire by a knife held tangent to the wire is used, and the slice so cut has the cross-section of a segment of a circle, the area shall be calculated as that of the segment of a circle whose diameter is that of the insulation. The height of the segment is the wall of insulation on the side from which the slice is taken. (The values are most easily obtained from a table giving the areas of segments of a unit circle for the ratio of the height of the segment to the diameter of the circle.)

(3) When the cross-section of the slice is not a segment of a circle, the area shall be calculated from a direct measurement of the volume or from the specific gravity and the weight of a known length of a uniform cross-section.

(4) When a portion of a sector of a circle has to be taken (as in the case of large conductors with thin walls) the area shall be calculated as the thickness times the width. (This applies either to a straight test piece or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

(5) When a portion of a sector of a circle has to be taken on large conductors with thick walls the area shall be calculated as the proportional part of the area of the total cross-section.

Number of Physical Test Specimens.

16. (*a*) *Less than 500 Feet.*—When an order calls for less than 500 ft., physical tests shall be waived.

(*b*) *Over 500 Feet.*—When an order calls for 500 ft. or more and is made into one or more coils, reels or lengths, samples shall be taken from 10 per cent of the coils, reels or lengths, but in all cases there shall be one sample taken.

Retests and Rejections, Physical Tests.

17. (*a*) *Retests.*—If a specimen fails to pass in either of the three tests prescribed in Section 14, two more specimens shall be taken from the same sample and the average of the results shall determine whether or not the sample complies with the requirements.

(*b*) *Rejections.*—When ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of individual test. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of individual test.

TABLE III.—VALUES OF TEST POTENTIALS, IN KILOVOLTS.

(ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Size of Conductors.	Thickness of Insulation, 64ths in.							
	2	3	4	5	6	7	8	10
18 A. W. G. or B. & S.	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
16 " "	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
14 " "	...	2.5	5.0	6.0	7.0	8.0	9.0	11.0
12 " "	...	2.5	5.0	6.0	7.5	8.5	9.5	11.5
10 " "	...	3.0	5.0	6.5	8.0	8.5	10.0	12.0
8 " "	...	3.0	5.0	7.0	8.0	9.5	11.0	13.0
6 " "	...	...	5.0	6.5	8.5	10.0	11.5	14.0
4 " "	...	...	4.5	6.5	8.5	10.0	11.5	14.5
2 " "	...	...	4.0	6.0	8.0	10.0	12.0	15.0
0 " "	...	...	...	5.5	8.0	10.0	12.0	15.5
00 " "	...	...	...	5.0	7.5	9.5	11.5	15.5
000 " "	...	...	...	5.0	7.5	9.5	11.5	15.5
0000 " "	...	...	...	4.5	7.0	9.0	11.5	15.5
250 000 C. M.	...	...	...	4.0	6.5	9.0	11.0	15.5
500 000 "	...	...	...	2.5	5.0	7.5	10.0	14.5
750 000 "	...	...	...	...	...	6.5	9.0	14.0
1 000 000 "	...	...	...	...	...	5.5	8.0	13.0
1 250 000 "	...	...	...	...	...	...	7.5	12.5
1 500 000 "	...	...	...	...	...	...	7.0	12.0
1 750 000 "	...	...	...	...	...	...	6.5	11.5
2 000 000 "	...	...	...	...	...	...	5.0	10.5

VI. ELECTRICAL PROPERTIES AND TESTS.

Electrical Properties.

18. (*a*) *Place.*—All electrical tests shall be made at the factory.

(*b*) *Requirements.*—Every coil, reel or length of wire, after vulcanization and before the application of paraffin or

TABLE IV.—INSULATION RESISTANCE, IN MEGOHM-MILES AT 60° F.[1]

(ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Size of Conductors.	Thickness of Insulation, 64ths in.																
	2	3	4	5	6	7	8	10	12	14	16	18	20	22	24	26	28
18 A. W. G. or B. & S.	1600	2050	2450	2800	3000	3200	3400	3750	4050	4300	4500	4700	4900	5000	5150	5300	5400
16 " "	1400	1800	2150	2400	2650	2850	3050	3400	3650	3950	4150	4350	4500	4650	4800	4900	5050
14 " "	....	1530	1850	2150	2350	2550	2650	3050	3350	3550	3800	3950	4100	4300	4400	4550	4650
12 " "	....	1350	1600	1850	2050	2250	2400	2750	3000	3250	3400	3600	3750	3900	4050	4150	4300
10 " "	....	1150	1350	1600	1800	2000	2150	2400	2650	2900	3100	3250	3400	3550	3700	3800	3900
8 " "	....	850	1050	1250	1450	1650	1750	2050	2200	2400	2600	2750	2900	3050	3150	3250	3350
6 " "	....	....	850	1050	1200	1350	1450	1750	1950	2100	2300	2450	2550	2700	2800	2900	3000
4 " "	....	....	750	850	1000	1150	1250	1450	1650	1850	2000	2150	2250	2400	2500	2600	2700
2 " "	....	....	650	750	850	950	1050	1250	1450	1600	1700	1850	1950	2100	2200	2300	2400
1 " "	....	....	600	650	750	850	1000	1150	1350	1450	1600	1750	1850	1950	2050	2150	2250
0 " "	....	....	....	600	700	800	950	1050	1200	1350	1500	1600	1700	1800	1900	2000	....
00 " "	....	....	....	550	650	750	850	950	1050	1250	1350	1500	1600	1700	1800	....	....
000 " "	....	....	....	500	600	650	750	850	1000	1150	1250	1350	1450	1550	....	....	....
0000 " "	....	....	....	450	550	600	650	800	950	1050	1150	1250	1350	1450	....	....	....
250 000 C. M.	....	....	....	400	475	575	625	725	875	1000	1100	1200	1275	....	....	....	....
350 000 "	....	....	....	350	425	475	525	675	775	850	950	1050	1125	....	....	....	....
500 000 "	....	....	....	300	375	400	475	575	675	750	850	900	....	....	....	....	....
750 000 "	....	....	....	....	....	325	400	475	525	625	700	775	....	....	....	....	....
1 000 000 "	....	....	....	....	....	300	325	400	475	550	625	....	....	....	....	....	....
1 250 000 "	....	....	....	....	....	....	325	375	425	500	575	....	....	....	....	....	....
1 500 000 "	....	....	....	....	....	....	300	325	400	475	....	....	....	....	....	....	....
1 750 000 "	....	....	....	....	....	....	275	300	375	450	....	....	....	....	....	....	....
2 000 000 "	....	....	....	....	....	....	200	275	325	425	....	....	....	....	....	....	....

NOTE.—For intermediate sizes, use values of next larger size.

[1] This table is based on the constant 4000 in the following formula:

$R = K \log \frac{D}{d}$, where R = resistance in megohms, K = Constant, D = diameter over insulation d = diameter over conductor.

any covering other than tape or braid used in vulcanization, shall successfully withstand a high voltage test as specified in Table III, and shall have an insulation resistance not less than that specified in Table IV. These tests shall be made after not less than 18 hours immersion in water, and while still immersed.

High Voltage Test.

19. The test voltage shall be applied for 5 minutes. The test shall be made in accordance with the Standardization Rules of the American Institute of Electrical Engineers. See Appendix I.

TABLE V.

(TESTS SHALL BE MADE AT TEMPERATURES WITHIN THE SCOPE OF THIS TABLE.)

Temperature.		Coefficient.	Temperature.		Coefficient.
Deg. Fahr.	Deg. Cent.		Deg. Fahr.	Deg. Cent.	
46	7.8	0.694	61	16.1	1.026
47	8.3	0.709	62	16.7	1.053
48	8.9	0.729	63	17.2	1.081
49	9.4	0.746	64	17.8	1.109
50	10.0	0.769	65	18.3	1.138
51	10.6	0.787	66	18.9	1.169
52	11.1	0.806	67	19.4	1.200
53	11.7	0.833	68	20.0	1.231
54	12.2	0.854	69	20.6	1.264
55	12.8	0.877	70	21.1	1.297
56	13.3	0.900	71	21.7	1.331
57	13.9	0.917	72	22.2	1.366
58	14.4	0.943	73	22.8	1.402
59	15.0	0.970	74	23.3	1.438
60	15.6	1.000	75	23.9	1.477

Insulation Resistance.

20. (*a*) *Method.*—This test shall be made in accordance with the Standardization Rules of the American Institute of Electrical Engineers. See Appendix I.

(*b*) *Temperature Coefficient.*—The insulation resistance (megohms) shall be reduced to that at 60° F. (15°.55 C.) by multiplying by the coefficient in Table V corresponding to the temperature at which test is made.

Rejections. Electrical Test.

21. Every coil, reel or length shall be rejected if it fails to comply with the electrical requirements herein specified.

(*C*) *Inspection.*

Inspection.

22. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the wire or cable to permit of arrangement for the inspection.

(*b*) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wire ordered, except compounding room. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications. Tests and inspection shall be made prior to shipment, at the place of manufacture.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the wire in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rehearing. 23. Samples of rejected material shall be preserved for two weeks from date of test report. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time. Sealed duplicate samples may be retained by the manufacturer at his option.

APPENDIX I.

EXTRACTS FROM STANDARDIZATION RULES OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

(Edition July 1, 1915.)

CONDUCTIVITY OF COPPER.

1. The following shall be taken as normal values for standard annealed copper:

(*a*) At a temperature of 20° C. the resistance of a wire of standard annealed copper 1 m. in length and of a uniform section of 1 sq. mm. is $1/58$ ohm $= 0.017241$ ohm.

(*b*) At a temperature of 20° C. the density of standard annealed copper is 8.89 g. per cubic centimeter.

(*c*) At a temperature of 20° C. the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is $0.00393 = 1/254.45$ . . . per degree Centigrade.

(*d*) As a consequence, it follows from (*a*) and (*b*) that at a temperature of 20° C. the resistance of a wire of standard annealed copper of uniform section, 1 m. in length and weighing 1 g. is $(1/58) \times 8.89 = 0.15328$ ohm.

HIGH VOLTAGE TEST.

(*a*) *Frequency.*

2. The frequency of the test voltage shall not exceed 100 cycles per second, and should approximate as closely as possible to a sine wave. The source of energy should be of ample capacity.

(*b*) *Rate of Increase of Voltage.*

3. The initially-applied voltage shall not be greater than the working voltage and the rate of increase shall not be over 100 per cent in 10 seconds.

INSULATION RESISTANCE TEST.

4. The apparent insulation resistance should be measured after the dielectric-strength test, measuring the leakage current after a one-minute electrification, with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained positive to the water.

APPENDIX II.

JOINT RUBBER INSULATION COMMITTEE PROCEDURE FOR THE ANALYSIS OF RUBBER COMPOUND.

Object of the Analysis.

1. The object of this procedure of analysis is to determine whether rubber compounds comply chemically with the accompanying specification which is intended to secure compounds containing 30 per cent of the best Hevea rubber, and mineral fillers.

Outline of Procedure.

2. The general procedure is shown in Fig. 1.

General.

3. Make the analysis upon the insulation after vulcanization and, whenever possible, before the saturation of the braid. Wipe the insulation thoroughly with a damp cloth to remove any adhering material, but do not remove waxy hydrocarbons from the surface.

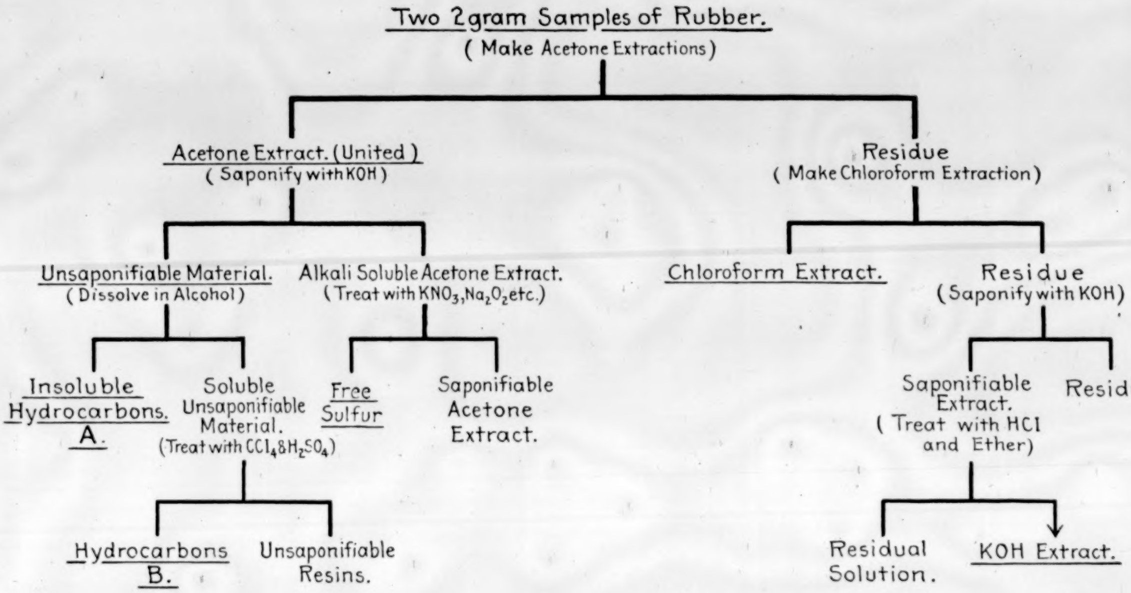
4. If, however, a saturated braided sample must be used, remove the braid and sandpaper the insulation to a depth oı at least 0.005 in. and wipe with a damp cloth. In such cases report the condition of the sample.

5. Perform all determinations in duplicate and take the average value arbitrarily as the true value. Duplicate determinations must check within the limits specified.

6. Make blanks on all determinations and deduct the results accordingly.

Sample.

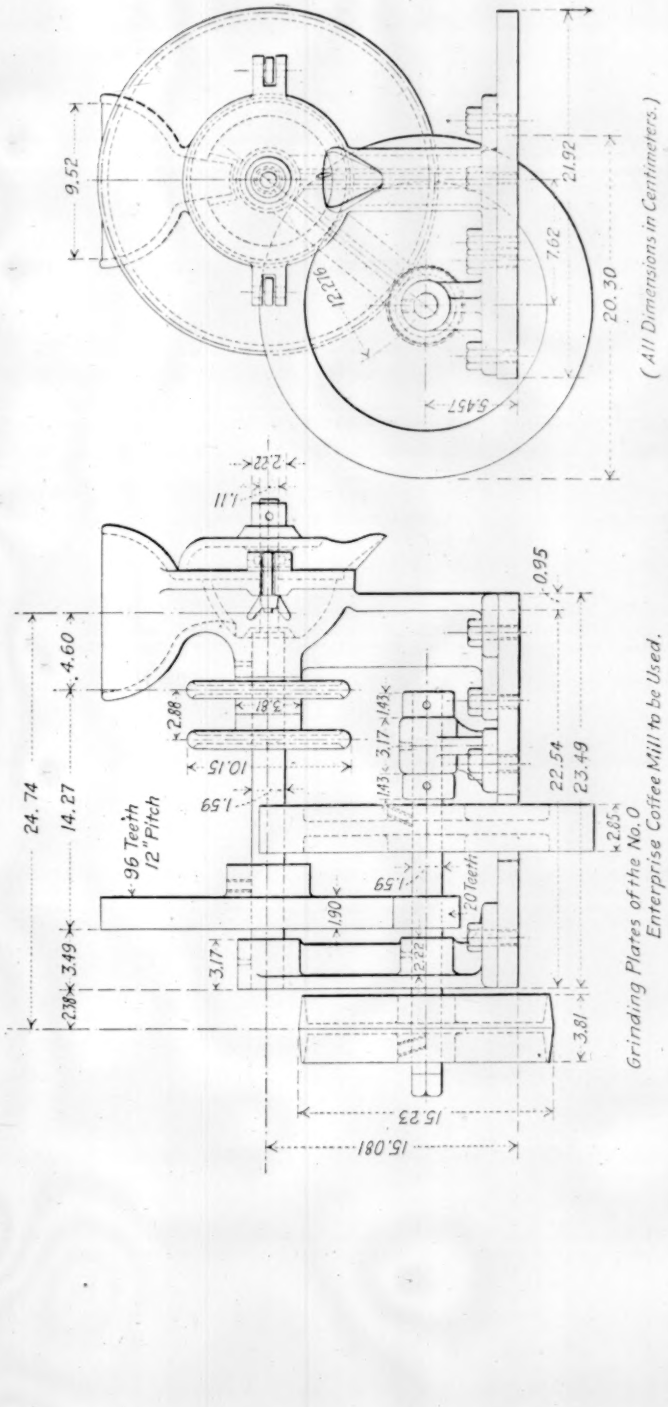
7. Remove the insulation entirely from sufficient wire to give a sample weighing about 25 g. Cut this into small strips and grind slowly in either a No. 0 Enterprise coffee mill or a


Two 2gram Samples of Rubber.
(Make Acetone Extractions)
Acetone Extract. (United)
(Saponify with KOH)
Residue
(Make Chloroform Extraction)
Unsaponifiable Material.
(Dissolve in Alcohol)
Alkali Soluble Acetone Extract.
(Treat with KNO_3, Na_2O_2 etc.)
Chloroform Extract.
Residue
(Saponify with KOH)
Insoluble Hydrocarbons. A.
Soluble Unsaponifiable Material.
(Treat with CCl_4 & H_2SO_4)
Free Sulfur
Saponifiable Acetone Extract.
Saponifiable Extract.
(Treat with HCl and Ether)
Residue
Hydrocarbons B.
Unsaponifiable Resins.
Residual Solution.
KOH Extract.

Total Waxy Hydrocarbons = A + B.

Weigh Substances with Names Underlined; Other Substances by Difference.

FIG. 1.—Outline of Method For Rubber Analysis.
(Exclusive of Fillers and Total Sulfur Determinations.)

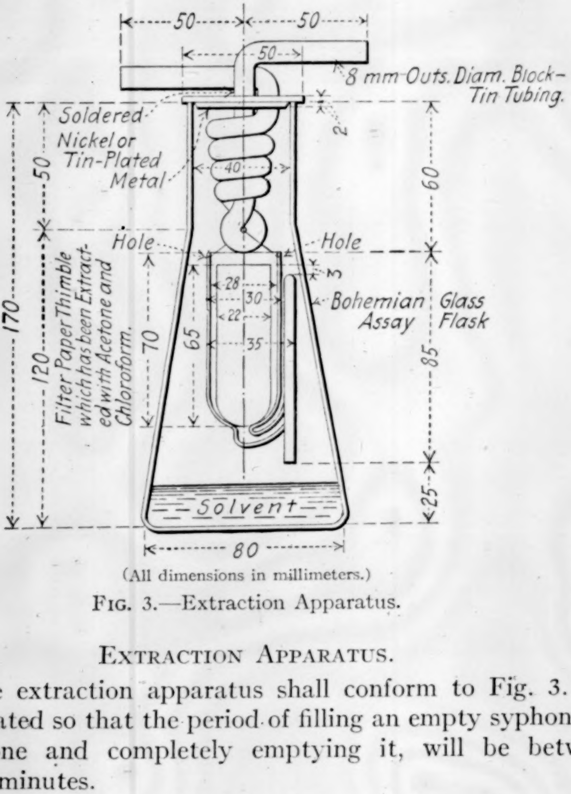

9.52
21.92
7.62
20.30
12.216
5.457
2.22
1.11
0.95
4.60
24.74
14.27
2.88
3.81
10.15
3.17
1.43
1.43
1.59
96 Teeth
12" Pitch
22.54
23.49
2.85
1.59
20 Teeth
1.90
3.49
3.17
2.22
2.38
3.81
15.23
15.081

(All Dimensions in Centimeters.)

Grinding Plates of the No. 0 Enterprise Coffee Mill to be Used.

FIG. 2.—Rubber Grinder.

mill such as shown by Fig. 2. Adjust the grinder so that not more than 20 per cent will pass through a 40-mesh sieve. Sift all the material through a 20-mesh sieve, regrinding what is retained on the sieve until the entire sample has passed through. The wires of the sieves shall be evenly spaced in both directions and shall be of 0.016 and 0.010 in. diameter in the 20- and 40-mesh sieves respectively. Remove with a strong magnet any metal that may have come from the grinder and thoroughly mix the sample.


50
50
50
8 mm Outs. Diam. Block-Tin Tubing.
Soldered Nickel or Tin-Plated Metal
2
40
50
60
170
120
Filter Paper Thimble which has been Extracted with Acetone and Chloroform.
Hole
Hole
3
28
30
22
35
70
65
Bohemian Assay
Glass Flask
85
25
Solvent
80

(All dimensions in millimeters.)

FIG. 3.—Extraction Apparatus.

EXTRACTION APPARATUS.

8. The extraction apparatus shall conform to Fig. 3. It shall be heated so that the period of filling an empty syphon cup with acetone and completely emptying it, will be between 2½ and 3½ minutes.

PREPARATION OF REAGENTS.

Acetone. 9. Acetone shall be freshly distilled over anhydrous K_2CO_3, using the fraction 56–57° C.

KOH. 10. Alcoholic KOH solution shall be of normal strength and shall be made freshly by dissolving the proper amount of KOH (purified by alcohol) in 95 per cent alcohol which has previously been distilled over KOH. The solution shall be allowed to stand for 24 hours and only the clear liquid used.

Ether. 11. Ether shall be washed with three successive portions of distilled water and distilled, using the fraction 34–36° C.

Chloroform. 12. Chloroform shall be pure and freshly distilled.

Carbon Tetrachloride. 13. Carbon tetrachloride shall be pure and freshly distilled.

14. Reagents not otherwise specified shall be c.p. Water shall be distilled.

ACETONE EXTRACT.

Acetone Extract. 15. Extract continuously with 60 cc. of acetone for 8 hours, two 2-g. samples that have been prepared within 24 hours. Unite the extracts in a weighed flask, using hot chloroform to rinse the flasks. Distill off the reagents and dry the flask and contents for 4 hours at 95–100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down the side of the flask.

UNSAPONIFIABLE MATERIAL.

Unsaponifiable Matter. 16. Add to the acetone extract 50 cc. of alcoholic KOH solution, boil under a reflux condenser for 2 hours, and evaporate to dryness, removing all alcohol. Add 10 cc. of water and 20 cc. of ether; heat until the wax, etc., are in solution, cool, transfer to a separatory funnel, wash out the flask with warm water and then cool, finally with two 20-cc. portions of ether. The water volume should be 100 cc. and the ether at least 40 cc. Shake vigorously for 2 minutes, and allow the solutions to separate thoroughly. Draw off the aqueous solution into a second funnel, leaving in the first funnel the ethereal solution and any flocculent material that may be present. Again rinse the flask with 20 cc. of ether and add it to the aqueous solution; shake vigorously for 2 minutes, and when separated draw off the aqueous solution and unite in the first funnel the ethereal solutions and any flocculent material. Repeat, shaking with 20-cc.

portions of ether until the extraction is complete, using at least 120 cc. of ether. Wash the flask and the funnel, from which the ethereal solution has been taken, with water, until they are free from alkali, subsequently using this wash water to wash the ethereal solution. Continue washing with water until it has been washed twice after it shows no alkaline reaction. Retain with the ethereal solution any flocculent material. Filter the ethereal solution from the flocculent material, through a small pellet of extracted cotton, into a weighed flask, washing first with ether and subsequently with hot chloroform, using this to rinse the original flask and both separatory funnels. Evaporate the solvents and dry the extract to constant weight at 95 to 100° C.; desiccate until cool and weight.

HYDROCARBONS A.

Hydrocarbons A.

17. Add 50 cc. absolute alcohol to the unsaponifiable material and warm until solution is as complete as possible. Cool the solution to −4 or −5° C. and maintain at this temperature for 1 hour by packing the flask in a mixture of ice and salt. Filter out the waxy hydrocarbons, using a funnel packed with ice and salt, and apply suction if necessary. Wash the flask and filter with about 25 cc. of 95 per cent alcohol, which has been previously cooled in the same temperature. Catch the filtrate in a flask which is afterwards cooled to −4 or −5° C. to make sure that all possible waxy hydrocarbons have been removed, and refilter if necessary. Dissolve the residue on the filter paper with hot chloroform, into the original flask. Evaporate the chloroform and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

HYDROCARBONS B.

Hydrocarbons B.

18. Evaporate the alcohol from the flask containing the alcoholic soluble unsaponifiable material, add 25 cc. carbon tetrachloride and transfer to a separatory funnel. Shake with concentrated H_2SO_4, drain off the discolored acid and repeat with fresh portions of acid until there is no longer any discoloration. After drawing off all the acid, wash the carbon tetrachloride solution with repeated portions of water until all traces of acid

are removed. Transfer the carbon tetrachloride solution to a weighed flask; evaporate off the solvent and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

FREE SULFUR.

Free Sulfur.

19. Add 2 g. KNO_3 to the aqueous solution and washings from the ethereal separation of the unsaponified material. Evaporate to dryness in a silver or nickel dish and heat to quiet fusion, avoiding contamination with sulfur fumes. Transfer with water to an evaporating dish, acidify with HCl, evaporate to dryness, and dehydrate silica. Add 2 cc. concentrated HCl, take up in water, filter and wash, making a volume of 200 cc. Heat to boiling and add slowly a slight excess of hot 10 per cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate the sulfur.

DEFINITION OF TERMS DESCRIBING COMPONENTS OF ACETONE EXTRACT.

Organic Extract.

20. The difference between the Acetone Extract and the Free Sulfur shall be called the Organic Extract.

Saponifiable Acetone Extract.

21. The difference between the Organic Extract and the Unsaponifiable Material shall be called the Saponifiable Acetone Extract.

Waxy Hydrocarbon.

22. The sum of the Hydrocarbons A and B shall be called the total Waxy Hydrocarbons.

Unsaponifiable Resins.

23. The difference between the Unsaponifiable Material and the Waxy Hydrocarbons shall be called Unsaponifiable Resins.

CHLOROFORM EXTRACT.

Chloroform Extract.

24. Extract continuously the residues from both of the acetone extractions (without necessarily removing the acetone that may be on them) for 4 hours with 60 cc. of chloroform, unite the extractions in a weighed flask, using hot chloroform to rinse the flasks. Distill off the solvent and dry the flask and contents for 2 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 1-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does

not appreciably run down the side of the flask. (If it is needful to wait after the acetone extraction, before starting the chloroform extraction, the sample must be kept in a vacuum of at least 50 mm. of mercury.)

ALCOHOLIC-POTASH EXTRACT.

Alcoholic KOH Extract.

25. Dry the residue from the chloroform extraction at 50 to 60° C. until odor of chloroform can no longer be detected, unite residues from the two 2-g. samples in a 200-cc. Erlenmeyer flask. Add 100 cc. alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution by decantation through an 11-cc. hardened filter paper into a beaker and wash twice, using each time 25 cc. hot absolute alcohol and then wash thoroughly with hot water. Wash any rubber on the filter paper back into the original flask and reserve this for the determination of the rubber hydrocarbons. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. of 5 normal HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portion of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

RUBBER HYDROCARBONS.

Rubber Hydrocarbon.

26. Add to the flask containing the rubber residue from the alcoholic KOH extraction, sufficient water to make the total volume of the solution 125 cc. and then add 25 cc. concentrated HCl. Heat for an hour at 97 to 100° C. Decant the supernatant liquid through a hardened filter paper on a Buch-

ner funnel 7 cm. diameter, using suction; wash the residue with 25 cc. hot water and decant. (While a Buchner funnel is recommended, it is permissible to use an 11-cm. hardened filter paper with platinum cone, in a 60-deg. funnel.) Perform this entire treatment with water and HCl three times and save the first and second decantations for the "organic matter" test described in Section 33. The rubber at this stage should be white and practically free from black specks of undissolved fillers; if not, continue the acid treatment until the black specks disappear. (If carbon is present, all the particles of rubber will be grayish, bluish, or black, depending on the form and quantity of carbon used. Black specks in light particles of rubber usually indicate the presence of lead sulfide which must be removed to prevent the formation of lead sulfate on igniting the residue *C*.) Add 150 cc. of hot water to the flask and let stand on a steam bath or hot plate for half an hour and decant through the filter paper, repeating until washings are free from chlorides. (See Section 33.) Transfer all the rubber in the flask to the filter paper and dry as much as possible by suction. Wash the rubber with 50 cc. of 95-per-cent alcohol, using suction. Transfer the entire residue to a weighing bottle. Dry at 95 to 100° C. for an hour, cool in a vacuum desiccator under reduced pressure and weigh. Dry for a half hour, cool and weigh, repeating this process until either constant weight is reached or the weight starts to increase. Let this weight be represented by C. Determine the ash (E) on a portion (D) of this residue (C) and sulfur (H) on the remaining portion (G). Also determine the sulfur (F) on the ash (E). Perform the ash determination as described under ash in Rubber Residue and the sulfur determinations as described under Total Sulfur. Then,

$$\text{Rubber hydrocarbons} = 100\,\frac{C}{4}\left(1 - \frac{H}{C} - \frac{E-F}{D}\right)$$

expressed as a percentage of the total sample.

ASH IN RUBBER RESIDUE.

27. Place about 1/2 g. (D) of residue C into a weighed porcelain crucible and heat gently, gradually driving off the **Ash in Rubber Residue.**

volatile matter. When the crucible has ceased to smoke, raise the temperature gradually to between 450 and 500° C., until all organic matter has been burned away, which is usually indicated by the ash becoming white. (an electric muffle furnace with pyrometer is recommended for this purpose.) Cool in a desiccator and weigh, the weight of ash being represented by *E* in the formula for rubber hydrocarbons. Make sulfur test on ash by the method described under Total Sulfur. If, however, the ash (*E*) is not over 0.08 *D*, the determination of sulfur in the ash may be omitted, and *F* assumed to be zero.

TOTAL SULFUR.

Total Sulfur.

28. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion, and then bring to quiet fusion for 15 to 20 minutes. Apply the heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate silica; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 100 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

SPECIFIC GRAVITY.

Specific Gravity.

29. The specific gravity shall be the ratio of the weight of a given volume of the rubber to the weight of an equal volume of water, both at 20° C. Cut strips of the largest applicable size from the conductor and use about 5 g. for the sample. Determine the specific gravity in the usual manner by means of a specific gravity bottle. Care must be taken that no air bubbles adhere to the sample.

CHECKS.

30. Specific gravity determinations shall check within 0.01. **Checks.** The other duplicate determinations shall check within the following limits expressed as percentages of the original sample.

DETERMINATION.	CHECK.
Acetone extract	0.10
Saponifiable acetone extract	0.10
Unsaponifiable resins	0.10
Waxy hydrocarbons	0.10
Free sulfur	0.05
Chloroform extract	0.10
Alcoholic potash extract	0.10
Rubber hydrocarbons	0.20
Total sulfur	0.10

INTERPRETATION.

31. The rubber shall be considered to be the sum of the **Interpretation.** rubber hydrocarbons, saponifiable acetone extract, unsaponifiable resins and chloroform and alcoholic potash extracts, expressed as percentages. If the chloroform extract is over 3.0 per cent of the rubber so calculated, subtract the excess from the rubber. If the KOH extract is over 1.8 per cent of the rubber as first calculated, subtract this excess also from the rubber.

RED LEAD.

32. Dissolve 1 g. of the sample in 75 cc. of xylol at a temperature of about 100° C. **Red Lead.** When the rubber is dissolved, the absence of any red particles indicates the absence of red lead. If red particles are present, filter the solution into a Gooch crucible and wash thoroughly with benzol, acetone and alcohol successively. Remove the felt and residue to a distilling flask, add HCl, and distill over the chlorine liberated by the lead peroxide, absorbing the gas in a solution of KI and starch. Not more than 0.1 cc. of N/10 thiosulfate shall be required to titrate the iodine liberated.

ORGANIC FILLERS.

33. Transfer the first and second decantations of the HCl **Organic Filler.** solutions to a carefully cleaned porcelain dish and add 20 cc.

concentrated H_2SO_4. Place dish on steam bath or hot plate to drive off water and HCl. A pronounced charring of the residue indicates the presence of organic matter soluble in water or hydrolyzed by HCl. Examine filter paper and rubber while decanting acid solution and washing free of chlorides. Some types of organic fillers not removed by water and HCl, would be plainly visible at this point. Place a small portion of residue *C* under a microscope and examine for fibrous and other characteristic organic material. If organic fillers are indicated and not clearly proven by this test, place 1 g. of the original sample in a beaker, add 50 cc. of xylol and heat on hot plate until the rubber is dissolved. Decant xylol solution and wash residue with ether several times by decantation. Dry residue and examine under the microscope.

STATEMENT OF RESULTS.

Statement of Results.

34. The results of the analysis shall be stated in the following form:

	PER CENT.
Acetone extract	
Saponifiable acetone extract	
Unsaponifiable resins	
Waxy hydrocarbons	
Free sulfur	
Chloroform extract	
Alcoholic potash extract	
Total sulfur	
Rubber	
Color of acetone extract (60 cc. vol.)	
Fluorescence in acetone extract solution (present or absent)	
Hydrocarbons A (consistency and color)	
Hydrocarbons B (solid or liquid)	
Color of chloroform extract (60 cc. vol.)	
Carbon (present or absent)	
Red lead (present or absent)	
Specific gravity	

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS FOR AIR-LINE HOSE FOR PNEUMATIC TOOLS.[1]

Serial Designation: D 46 – 17 T.

The specifications for this material are issued under the fixed designation D 46; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These specifications cover wrapped air-line hose suitable for air tools working at not more than 125 lb. pressure and for vacuum cleaning outfits.

I. MANUFACTURE.

Construction. 2. The hose shall consist of:

(*a*) An inner rubber tube;
(*b*) Cotton reinforcement;
(*c*) An outer rubber cover;
(*d*) When specified, an extra covering of cotton or wire.

Rubber Tube. 3. The rubber tube shall be smooth, uniform in quality and thickness, and free from injurious defects.

Cotton Reinforcement. 4. The reinforcement shall consist of cotton canvas plies made from duck evenly and firmly woven from good cotton, as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice. It shall be well frictioned on both sides with a rubber compound suitable for the required service. The plies shall be laid on the bias and be sufficiently strong to enable the hose to successfully withstand the hydrostatic pressure test; yet at the same time be soft and pliable.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. E. A. Barrier, Chairman of Committee D-11 on Rubber Products, 31 Milk St., Boston, Mass.

Rubber Cover. 5. The rubber cover shall be uniform in quality and thickness and be free from injurious defects.

Extra Covering. 6. When specified, the hose shall be given an extra covering of one of the following, as specified:

(*a*) An armor of half-round wire $\frac{7}{32}$ by $\frac{5}{64}$ in., spaced $\frac{1}{4}$ in. apart;
(*b*) Canvas;
(*c*) Cotton Braid.

The canvas or cotton braid shall be equal in quality to the cotton canvas specified in Section 4, and when free from rubber shall weigh not less than 8 oz. per sq. yd.

II. PHYSICAL PROPERTIES AND TESTS.

Standard Methods. 7. Where applicable, references are made below to the Standard Methods for Testing of Cotton Rubber-Lined Hose (D 15–15) of the American Society for Testing Materials.[1]

Temperature of Testing Room and Samples. 8. The temperature for tests of rubber parts shall be as defined in Standard Methods D 15, Section 19.

Samples for Testing of Rubber Parts. 9. Prior to the hydrostatic test specified in Section 12 (*b*), a section 16 in. long may be cut at any place from each length for subjection to the following tests:

Friction Test. 10. The quality of the rubber friction binding the plies together shall be determined by suspending a 15-lb. weight from the separated end of the duck of a 1-in. test ring cut from the 16-in. sample described above, the force being applied radially. The separation shall be not greater than at the rate of 1 in. per minute; the test shall extend for ten minutes when the size of the hose permits.

Tests of Rubber Tube and Cover. 11. (*a*) The methods of testing the rubber tube and cover shall be in accordance with Standard Methods D 15, Sections 18, 20 (*a*), (*b*), (*c*), 22, 23, 24, 25.

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[1] 1916 Book of A.S.T.M. Standards, p. 580.

(*b*) Test pieces shall be cut longitudinally from the hose.

(*c*) When stretched from 2 in. to 9 in., the stress upon the tube shall be at least 900 lb. per sq. in. and that upon the cover shall be at least 800 lb. per sq. in.

(*d*) The set, or permanent elongation, shall not exceed 25 per cent.

(*e*) The tensile strength shall not be less than 1500 lb. per sq. in. for the tube and 1300 lb. per sq. in. for the cover.

(*f*) Both tube and cover shall have an elongation at the breaking point of at least from 2 to 10½ in.

Hydrostatic Pressure Tests.

12. The method of conducting the hydrostatic pressure tests shall be in accordance with Standard Methods D 15, Section 26.

(*a*) Each length of hose shall be subjected to a proof pressure test of 250 lb. per sq. in. for five minutes to expose imperfections.

(*b*) From each lot of ten lengths or less of hose inspected, one length shall be further subjected to a pressure test of 500 lb. per sq. in. for five minutes which it shall withstand without bursting.

On large orders the number of tests may be reduced to not less than three at the option of the inspector representing the purchaser.

III. STANDARD LENGTHS, SIZES, PLY AND GAGES.

Length.

13. Unless otherwise specified, the hose shall be furnished in 50-ft. lengths. The ends of each length shall be uncapped and without fittings.

Sizes.

14. The minimum tube and cover thickness shall be as follows:

SIZE, IN.	MINIMUM TUBE THICKNESS, IN.	MINIMUM COVER THICKNESS, IN.
3/8	1/16	3/64
1/2	1/16	3/64
5/8	1/16	3/64
3/4	3/32	1/16
1	3/32	1/16
1 1/4	3/32	1/16

IV. MARKING.

Marking. 15. Each 50-ft. length of hose shall have inlaid in rubber in three places, namely, midway between the ends and within 10 ft. of each end, a brand showing the name of the manufacturer, the month and year of manufacture, the trade name of hose, and the legend "Air 125 lb. A.S.T.M. Specifications."

V. INSPECTION.

Inspection. 16. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit the purchaser to arrange for the inspection.

(*b*) The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rehearing. 17. Samples of rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the test, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE TESTS
FOR
LUBRICANTS.[1]

Serial Designation: D 47 – 17 T.

These tests are issued under the fixed designation D 47; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

SPECIFIC GRAVITY.

Specific Gravity.

1. Specific Gravity may be determined by hydrometer, Westphal balance, or pyknometer, providing these instruments are verified. The observation shall be taken with the sample at 15°.56 C. compared with water of the same temperature.

STANDARD TEMPERATURES FOR VISCOSITY.

Temperatures for Viscosity.

2. Determinations of viscosity shall be made at the following temperatures:

20° C., 40° C., 55° C., 100° C.

CLOUD AND POUR TESTS FOR PETROLEUM OILS EXCEPT STEAM CYLINDER AND BLACK OILS.

Cloud Test.

3. The cloud test indicates the point at which paraffin wax or other solid substances crystallize out or separate from solution in the oil.

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[1] Criticisms of these Tentative Tests are solicited and should be directed, preferably before January 1, 1918, to Mr. C. P. Van Gundy, Chairman of Committee D-2 on Lubricants, Chief Chemist, B. & O. R. R., Montclare, Baltimore, Md.

Put the oil to be tested in a glass jar or bottle, approximately 1¼ in. in inside diameter and 4 to 5 in. high, to a height of about 1¼ in. or sufficient to reach ¼ in. above the mercury bulb of the thermometer. The thermometer used is the so-called cold-test thermometer, which is specially made for this purpose and has a bulb ¼ to ⅜ in. long. Insert the thermometer through a tight-fitting cork so that it is held centrally in the jar, with the lower end of the bulb ½ in. from the bottom of the jar. Then place the cold-test jar in a metal or glass jacket 4 to 5 in. high, having inside diameter ½ in. larger than the outside diameter of the test jar. A disk of felt, cork or wax, ¼ in. in thickness, is placed in the bottom of the jacket. Care should be taken that the test jar is placed in the center of the jacket, so that it does not touch the sides at any point. Then put the whole apparatus into the refrigerating mixture and at every drop in temperature of 2° F. when near the expected cloud test, remove the jar from the jacket and inspect, being careful not to disturb the oil by moving the thermometer or otherwise. When the lower half of the sample becomes opaque through chilling, read the thermometer. This reading shall be taken as the "cloud test" of the oil.

Pour Test. 4. The pour test indicates the temperature at which a sample of oil in cylindrical form of specified diameter and length will just flow under specified conditions.

In making this test the same bottle and quantity of oil are used as for the cloud test, and the pour test may, if desired, be made after the cloud test has been determined; in the great majority of cases the cloud test being the higher. In making the pour test, place the jar containing the oil in a close-fitting metal jacket provided at the bottom with a disk of felt or cork ¼ in. thick. Place this in the freezing mixture. At each drop in temperature of 5° F. remove the bottle from the jacket and tilt it until the oil begins to flow; just sufficiently tilted but no more. In the extreme case, the bottle should be tilted to the horizontal. When the oil has become solid around the thermometer and will not flow, the previous 5° point shall be taken as the "pour test" of the oil.

Preferably, the cold should be applied so that the pour test will be completed in approximately one-half hour. The materials used in the freezing mixture may be ice, calcium chloride or sodium chloride, or solid carbon dioxide with acetone, depending upon the temperature desired in making the tests. For oils congealing or solidifying above +35° F. pounded ice is used. From +35 to +15° F., a mixture of pounded ice and a small addition of salt, 1 : 20 by volume, may be taken. For temperatures from +15 to −5° F., also use an ice-and-salt mixture, adding about one-third salt. The salt should be very dry and granulated fine enough to pass through a 20-mesh sieve. From zero to −25° F., a mixture of ice and calcium chloride is used. For temperatures lower than −5° F., however, it will be found very convenient to use solid carbon dioxide and acetone, by which any desired temperature down to −70° F. can be obtained, or even lower. This freezing mixture is made as follows:

Take a sufficient amount of dry acetone and put it into a covered metal beaker, copper or nickel; put the beaker into an ice-salt mixture and when the temperature of the acetone reaches +10° F., or below, add by degrees solid carbon dioxide, until the desired temperature is reached. To get the solid carbon dioxide, take an ordinary liquefied carbon-dioxide cylinder and invert it, open the valve carefully and let the gas run out into a chamois-skin bag. By the rapid evaporation the dioxide becomes solid.

COLD TEST FOR STEAM CYLINDER AND BLACK OILS.

Cold Test.

5. The object of the cold test is to determine the lowest temperature at which oil will flow from one end of a container to the other, in case it should become frozen and the resulting solid oil stirred till it has assumed a sufficiently pasty consistency to flow. The test is conducted by freezing an ounce of the oil solid in an ordinary 4-oz. oil sample bottle, using a freezing mixture if necessary. A thermometer should then be introduced into the frozen mass, and after it has become cold, the bottle containing the congealed oil is removed from the cooling medium. The frozen oil is thoroughly stirred with a thermometer until the mass will run from one end of the bottle to the other, and at this moment the temperature as indicated is recorded. The reading is the cold test of the oil.

If the figures indicating the cold test are inside the bottle and covered by the softened oil, the reading can be obtained by grasping the bottle by the neck with one hand, having in the same hand a piece of waste, which encloses the thermometer. The thermometer is then withdrawn through the waste with the other hand for a sufficient distance to enable the operator to see the end of the mercury column and read the temperature.

FREE ACID.

Free Acid. 6. Accurately weigh 10 g. of the oil into a flask, add 50 cc. of 95-per-cent alcohol which has been neutralized with weak caustic soda, and heat to the boiling point. Agitate the flask thoroughly in order to dissolve the free fatty acids as completely as possible. Titrate while hot with aqueous tenth-normal alkali, free from carbonate, using phenolphthalein, alkali blue or tumeric as an indicator, agitating thoroughly after each addition of alkali.

Express results either as percentage of oleic acid or as acid number (milligrams of potassium hydroxide required to saturate the free acids in 1 g. of fat or oil).

1 cc. of tenth-normal alkali = 0.0282 gram of oleic acid. Alkali, 1 cc. of which is equivalent to 0.00996 g. of KOH, and 1 cc. of which is equivalent to 0.5 per cent of oleic acid, may be used.

CARBON RESIDUE.[1]

Apparatus. 7. The apparatus (see Fig. 1) consists of:

(*a*) Porcelain crucible, wide form, glazed throughout, 25 to 26-cc. capacity, 46 mm. in diameter.

(*b*) Skidmore iron crucible, 45-cc. (1½ oz.) capacity, 65 mm. in diameter, 37 to 39 mm. high with cover, without delivery tubes and one opening closed.

(*c*) Wrought-iron crucible with cover, about 180 cc. capacity, 80 mm. diameter, 58 to 60 mm. high. At the bottom of this crucible a layer of sand is placed about 10 mm. deep or enough to bring the Skidmore crucible with cover on nearly to the top of the wrought-iron crucible.

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[1] This method is a modification by P. H. Conradson of his original method and apparatus for Carbon Test and Ash Residue in Petroleum Lubricating Oils. See *Proceedings*, Eighth International Congress of Applied Chemistry, New York, September, 1912, Vol. 1, p. 131. Also reprint in the *Journal of Industrial and Engineering Chemistry*, Vol. 4, No. 11, November, 1912.

(*d*) Triangle, pipe stem covered, projection on side so as to allow flame to reach the crucible on all sides.

(*e*) Sheet iron or asbestos hood provided with a chimney about 2 to $2\frac{1}{2}$ in. high, $2\frac{1}{8}$ to $2\frac{1}{4}$ in. in diameter to distribute the heat uniformly during the process.

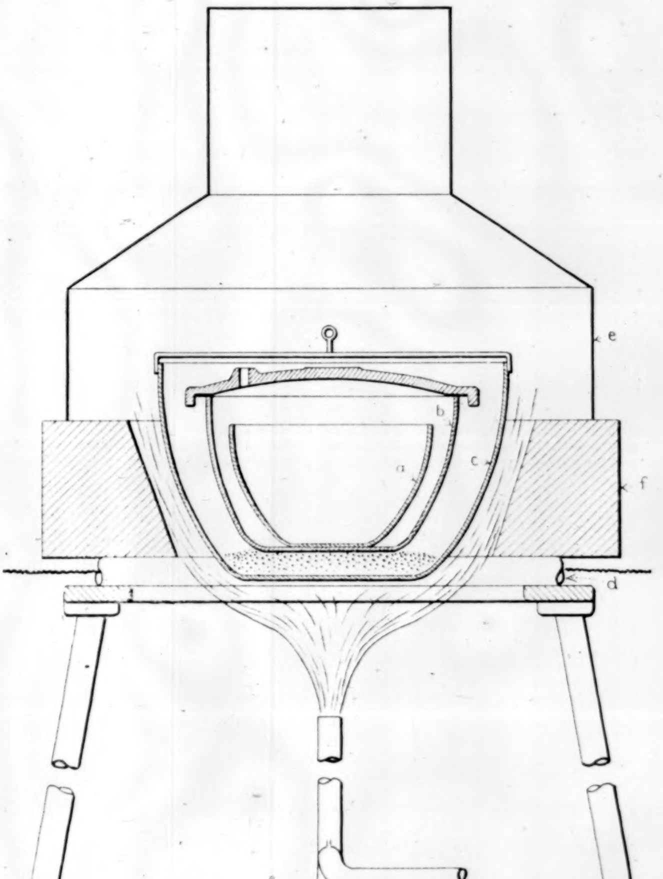

FIG. 1.—Apparatus for Determining Carbon Residue.

(*f*) Asbestos block.

Method. 8. The test shall be conducted as follows:

Ten grams of the oil to be tested are weighed in the porcelain crucible, which is placed in the Skidmore crucible and these two crucibles set in the larger iron crucible, being careful to have the Skidmore crucible set in the center of the iron crucible, covers being applied to the Skidmore and iron crucibles. Place on triangle and suitable stand with asbestos block and cover with sheet iron or asbestos hood (so as to distribute the heat uniformly during the process).

Heat from a Bunsen burner or other burner is applied with a high flame surrounding the large crucible, as shown in Fig. 1, until vapors from the oil start to ignite over the crucible, when the heat is slowed down so that the vapor (flame) will come off at a uniform rate. (The flame from the ignited vapors should not extend over 2 in. above the sheet iron hood.) After the vapor ceases to come off the heat is increased as at the start and kept so for five minutes, making the lower part of large crucible red hot, after which the apparatus is allowed to cool somewhat before uncovering the crucible. The porcelain crucible is removed, cooled in a desiccator and weighed.

The entire process should require about one-half hour to complete when heat is properly regulated. It will depend somewhat upon the kind of oil tested, as a very thin, rather low-flash-point oil will not take as long a time as a heavy, thick, high-flash-point oil.

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TENTATIVE TEST
FOR
TOUGHNESS OF ROCK.[1]

Serial Designation: D 3 – 17 T.

This test is issued under the fixed designation D 3; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Definition. 1. Toughness, as applied to rock, is the resistance offered to fracture under impact, expressed as the final height of blow required of a standard hammer to cause fracture of a cylindrical test specimen of given dimensions.

Sampling. 2. Quarry samples of rock from which test specimens are to be prepared shall measure at least 6 in. on a side and at least 4 in. in thickness, and when possible shall have the plane of structural weakness[2] of the rock plainly marked thereon. Samples should be taken from freshly quarried material, and only from pieces which show no evidences of incipient fracture due to blasting or other causes. The samples should preferably be split from large pieces by the use of plugs and feathers and not by sledging. Commercial stone-block samples from which test specimens are to be prepared shall measure at least 3 in. on each edge.

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1918, to Mr. L. W. Page, Chairman of Committee D-4 on Road Materials, Office of Public Roads and Rural Engineering, Washington, D. C.

This test, when adopted as standard, will supersede the present Standard Test for Toughness of Macadam Rock (D 3-08), 1916 Book of A.S.T.M. Standards, p. 526.

[2] The plane of structural weakness may in certain cases be the rift, cleavage, or bedding plane.

Size and Form of Test Specimen.

3. Specimens for test shall be cylinders prepared as described in Section 4, 25 mm. in height and from 24 to 25 mm. in diameter. Three test specimens shall constitute a test set. The ends of the specimen shall be plane surfaces at right angles to the axis of the cylinder.

Preparation of Test Specimens.

4. One set of specimens shall be drilled perpendicular and another parallel to the plane of structural weakness of the rock, if such plane is apparent. If a plane of structural weakness is not apparent, one set of specimens shall be drilled at random. Specimens shall be drilled in a manner which will not subject the material to undue stresses and which will insure the specified dimensions.[1] The ends of the cylinders may be sawed by means of a band or diamond saw,[2] or in any other way which will not induce incipient fracture, but shall not be chipped or broken off with a hammer. After sawing, the ends of the specimens shall be ground plane with carborundum or emery on a cast-iron lap until the cylinders are 24 mm. in length.

Impact Machine.

5. Any form of impact machine which will comply with the following essentials may be used in making the test:

(*a*) A cast-iron anvil weighing not less than 50 kg., firmly fixed upon a solid foundation;

(*b*) A hammer weighing 2 kg., arranged so as to fall freely between suitable guides;

(*c*) A plunger made of hardened steel and weighing 1 kg., arranged to slide freely in a vertical direction in a sleeve, the lower end of the plunger being spherical in shape with a radius of 1 cm.;

(*d*) Means for raising the hammer and for dropping it upon the plunger from any specified height from 1 to not less than 75 cm., and means for determining the height of fall to approximately 1 mm.;

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[1] The form of diamond drill described in *Bulletin No. 347*, U. S. Department of Agriculture, pp. 6–7, is recommended, and should prove satisfactory if the instructions are strictly followed.

[2] A satisfactory form of diamond saw is described in *Bulletin No. 347*, U. S. Department of Agriculture, pp. 7–9.

(*e*) Means for holding the cylindrical test specimen securely on the anvil without rigid lateral support, and under the plunger in such a way that the center of its upper surface shall, throughout the test, be tangent to the spherical end of the plunger at its lowest point.

Method of Testing.

6. The test shall consist of a 1-cm. fall of the hammer for the first blow, a 2-cm. fall for the second blow, and an increase of 1-cm. fall for each succeeding blow until failure of the test specimen occurs.

Recording and Reporting Results.

7. The height of the blow in centimeters at failure shall be the toughness of the test specimen. The individual and the average toughness of three test specimens shall be reported when no plane of structural weakness is apparent. In cases where a plane of structural weakness is apparent, the individual and average toughness of the three specimens in each set shall be reported and identified. Any peculiar condition of a test specimen which might affect the result, such as the presence of seams, fissures, etc., shall be noted and recorded with the test result.

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TENTATIVE TEST
FOR
DETERMINATION OF APPARENT SPECIFIC GRAVITY OF COARSE AGGREGATES.[1]

Serial Designation: D 30 – 17 T.

This test is issued under the fixed designation D 30; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917.

The apparent specific gravity shall be determined in the following manner:

1. The sample, weighing 1000 g. and composed of pieces approximately cubical or spherical in shape and retained on a screen having 1.27-cm. (½-in.) circular openings, shall be dried to constant weight at a temperature between 100 and 110° C. (212 and 230° F.), cooled, and weighed to the nearest 0.5 g. Record this weight as weight *A*. In the case of homogeneous material, the smallest particles in the sample may be retained on a screen having 1¼-in. circular openings

2. Immerse the sample in water for 24 hours, surface-dry individual pieces with aid of a towel or blotting paper, and weigh. Record this weight as weight *B*.

3. Place the sample in a wire basket of approximately ¼-in. mesh, and about 12.7 cm. (5 in.) square and 10.3 cm. (4 in.)

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1918, to Mr. L. W. Page, Chairman of Committee D-4 on Road Materials, Office of Public Roads and Rural Engineering, Washington, D. C.

deep, suspend in water[1] from center of scale pan, and weigh. Record the difference between this weight and the weight of the empty basket suspended in water as weight *C*. (Weight of saturated sample immersed in water.)

4. The apparent specific gravity shall be calculated by dividing the weight of the dry sample (*A*) by the difference between the weights of the saturated sample in air (*B*) and in water (*C*), as follows:

$$\text{Apparent Specific Gravity} = \frac{A}{B-C}.$$

5. Attention is called to the distinction between apparent specific gravity and true specific gravity. Apparent specific gravity includes the voids in the specimen and is therefore always less than or equal to, but never greater than the true specific gravity of the material.

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[1] The basket may be conveniently suspended by means of a fine wire hung from a hook shaped in the form of a question mark with the top end resting on the center of the scale pan.

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TENTATIVE TESTS
FOR
MOLDED INSULATING MATERIALS.[1]

Serial Designation: D 48 – 17 T.

These tests are issued under the fixed designation D 48; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Scope. 1. These tests are intended to apply to all solid insulating materials that are formed in molds or between platens by the application of pressure, either with or without heat.

I. PHYSICAL PROPERTIES AND TESTS.

(*A*) *Mechanical.*

TENSILE STRENGTH.

Specimen. 2. The standard test specimen shown in Fig. 1 shall be used for the tension test. It shall be molded in a hardened and ground steel mold to the dimensions given in Fig. 1.

Apparatus. 3. Any standard testing machine may be used. Special clips (see Fig. 1) of hardened steel shall be used, hung from links held in the jaws of the machine, so that the pull is central at all times, to avoid any transverse strain.

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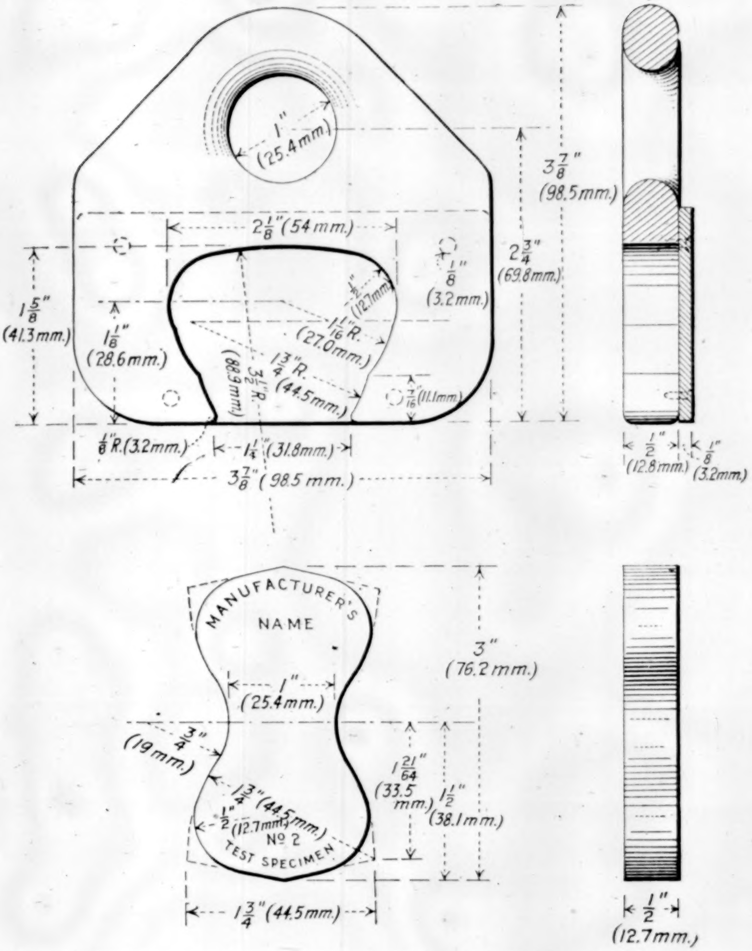
[1] Criticisms of these Tentative Tests are solicited and should be directed, preferably before January 1, 1918, to Mr. C. E. Skinner, Chairman of Committee D-9 on Electrical Insulation, W. E. & M. Co., East Pittsburgh, Pa.


1" (25.4 mm.)
$3\frac{7}{8}$" (98.5 mm.)
$2\frac{1}{8}$" (54 mm.)
$2\frac{3}{4}$" (69.8 mm.)
$\frac{1}{8}$" (3.2 mm.)
$\frac{1}{2}$" (12.7 mm.)
$1\frac{1}{16}$" R. (27.0 mm.)
$1\frac{3}{4}$" R. (44.5 mm.)
$3\frac{1}{2}$" R. (88.9 mm.)
$\frac{7}{16}$" (11.1 mm.)
$1\frac{5}{8}$" (41.3 mm.)
$1\frac{1}{8}$" (28.6 mm.)
$\frac{1}{8}$" R. (3.2 mm.)
$1\frac{1}{4}$" (31.8 mm.)
$3\frac{7}{8}$" (98.5 mm.)
$\frac{1}{2}$" (12.8 mm.)
$\frac{1}{8}$" (3.2 mm.)
MANUFACTURER'S NAME
1" (25.4 mm.)
3" (76.2 mm.)
$\frac{3}{4}$" (19 mm.)
$1\frac{21}{64}$" (33.5 mm.)
$1\frac{1}{2}$" (38.1 mm.)
$1\frac{3}{4}$" (44.5 mm.)
$\frac{1}{2}$" (12.7 mm.)
No 2
TEST SPECIMEN
$1\frac{3}{4}$" (44.5 mm.)
$\frac{1}{2}$" (12.7 mm.)

Make Steel Mold to these Dimensions. Limits ± 0."002 (0.05 mm.)

FIG. 1.—Tension Test Specimen (Specimen No. 2).

Method. 4. (*a*) Six specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after heating in an oven for one hour at a temperature which is 10° C. (18° F.) below the softening point of the material, as determined under Part (*C*), Sections 22 to 25. The test shall be made while the specimens are hot, with a permissible variation of ±5 per cent from the temperature taken.

Three specimens shall be tested after they have been entirely immersed in distilled water for 48 hours at normal room temperature. The specimens shall be pulled apart at normal room temperature of about 21° C. (70° F.) after the surface water has been removed by wiping with a dry cloth.

(*b*) The test specimen shall be pulled apart at such a speed that the beam can be kept well balanced. Make all tests at normal room temperature of about 21° C. (70° F.). Measurements may be taken at intervals during the test to show the elongation of the specimen when required for elastic materials.

Report. 5. The results of the test shall be reported in the following order:

(*a*) The breaking load of each specimen in kilograms or pounds;

(*b*) The thickness in centimeters or inches as measured by micrometer at the point of fracture;

(*c*) The average ultimate tensile strength in kilograms per square centimeter or in pounds per square inch, as calculated from the actual area of the specimen measured at the point of fracture;

(*d*) State the character of the material tested and describe how it acts under strain;

(*e*) The speed in centimeters or inches per minute at which the jaws traveled during the test.

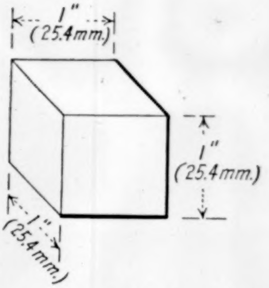
COMPRESSIVE STRENGTH.

Specimen. 6. The test specimen shall be molded in the form of a cube from a hardened steel mold, ground to the dimensions shown in Fig. 2.

Apparatus. 7. Any standard testing machine may be used. The pressure head used for standard compressive strength test on cement blocks is satisfactory for this purpose. Place a sheet of lead $\frac{1}{16}$ in. thick both above and below the specimen to adjust irregularities.

Method. 8. (*a*) Six specimens shall be crushed in the condition in which they are received.

Three specimens shall be crushed after heating for one hour at a temperature which is 10° C. below the softening point of the material, as determined under Part (*C*), Sections 18 to 21. The test shall be made while the specimens are hot, with a permissible variation of ±5 per cent from the temperature taken.



Manufacturer's Name and "Test Specimen No. 3" Molded on Top in Small Round Body Raised Letters.
Make Steel Mold to these Dimensions.
Limits ± 0."002 (0.05mm.)

FIG. 2.—Compression Test Specimen (Specimen No. 3).

Three specimens shall be crushed after immersion in distilled water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied at such a rate of speed that will permit the beam to be kept well balanced, from zero load until the specimen is crushed. For best results use the slowest possible speed.

Report. 9. The results of the test shall be reported in the following order:

(*a*) The dimensions of each specimen in millimeters or in inches;

(*b*) The breaking load in kilograms or in pounds, on each specimen at the first sign of failure.

(*c*) The average ultimate compressive strength in kilograms per square centimeter or in pounds per square inch, of each set of specimens, calculated from the measured area of each specimen before the load is applied.

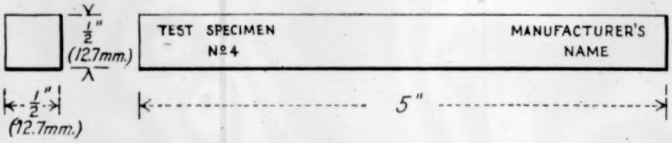
(*d*) State the general character of the material tested and describe how it acts under the applied load;

(*e*) The speed in centimeters or inches per minute at which the jaws traveled during the test.

TRANSVERSE STRENGTH.

Specimen. 10. The test specimen shall be molded from a hardened steel mold, ground to the dimensions shown in Fig. 3.

Apparatus. 11. Any standard testing machine may be used. The specimen shall be supported on two steel blocks, with corners rounded to $1\frac{1}{2}$-mm. ($\frac{1}{16}$-in.) radius. These supports shall be 100 mm. (3.94 in.) apart. The load shall be applied on top of this specimen by means of a wedge-shaped pressure piece, the edge of which is rounded to a 3-mm. ($\frac{1}{8}$-in.) radius, extending across the specimen with the edge parallel to the edges of the two supports. The angle of the wedge shall be approximately 45 deg., and the load shall be applied at right angles to the specimen midway between the supports. The specimen shall be laid flat upon the supports at equal distances from the edges at each end.



Make Steel Mold to these Dimensions. Limits ±0."002 (0.05 mm.)

FIG. 3.—Transverse Test Specimen (Specimen No. 4).

Method. 12. (*a*) Six specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after immersion in distilled water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied at as slow a speed as possible, so that the beam may be kept well balanced from zero load until the first sign of failure. All tests shall be made at room temperature of about 21° C. (70° F.). Measurements of the deflection may be taken for very elastic materials.

Report.

13. The results of the test shall be reported in the following order:

(*a*) The thickness of each specimen as measured by micrometer in millimeters or in inches;

(*b*) The actual breaking load of each specimen in kilograms or in pounds at the first sign of failure.

(*c*) The maximum fiber stress in kilograms per square centimeter or in pounds per square inch calculated by the formula,

$$S = \frac{3\,PL}{2\,BD^2},$$

in which S = maximum fiber stress, P = load applied, L = distance between the supports, B = width of specimen, and D = depth of specimen;

(*d*) The rate at which the load was applied;

(*e*) The amount of deflection in millimeters or inches.

(*B*) *Electrical.*

DIELECTRIC STRENGTH.

Specimen.

14. The test specimen shall be molded to the dimensions shown in Fig. 4. The mold shall be hardened and ground to these dimensions. If the material cannot be molded to the full height shown, the height can be reduced to 1¼ in., other dimensions remaining the same.

Apparatus.

15. (*a*) Any well-designed high tension testing transformer, connected to an alternating current supply having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall not be less than 5 KVA. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point. The control may be made by generator field regulation, by the potentiometer method, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than ten per cent from a sinusoidal shape.

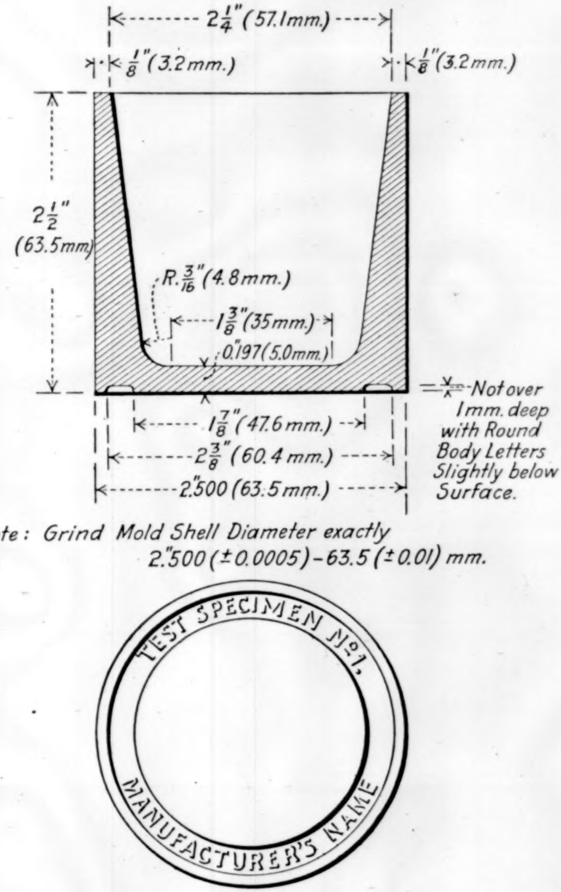
(*c*) The voltage may be measured by any approved method, preferably by connecting a voltmeter to an auxiliary ratio transformer coil, reading square root of mean square volts in the primary of the testing transformer. A voltmeter on the low tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

Some protection is desirable in the high tension circuit of testing transformers where the voltage is from 25,000 to 100,000 volts, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils be used in series with the high tension terminals, it should not be greater than that which will limit the high tension current to double the normal rated current of the testing transformer.

When a spark gap is used a non-inductive resistance of about 1 ohm per volt may be inserted in series with one terminal of the spark gap, to damp high frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible and in series with the test specimen. If the test is made with one side grounded this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded the resistance shall be inserted one-half on each side of the spark gap. Water tube resisters are preferable to carbon for this purpose, as carbon resistance may become very low at high voltage.

(*d*) The apparatus used shall meet the requirements of the Standardization Rules of the American Institute of Electrical Engineers.

Method. 16. (*a*) Voltage shall be applied to the test specimen by placing a wet clay pat about $\frac{1}{4}$ in. thick inside the specimen and extending all around to the wall and another wet clay pat


2¼" (57.1 mm.)
⅛" (3.2 mm.)
⅛" (3.2 mm.)
2½" (63.5 mm)
R. 3/16" (4.8 mm.)
1⅜" (35 mm.)
0.″197 (5.0 mm.)
1⅞" (47.6 mm.)
2⅜" (60.4 mm.)
2.″500 (63.5 mm.)
Not over 1 mm. deep with Round Body Letters Slightly below Surface.
TEST SPECIMEN No. 1.
MANUFACTURER'S NAME

Note: Grind Mold Shell Diameter exactly 2.″500 (±0.0005) – 63.5 (±0.01) mm.

Make Steel Mold to these Dimensions.
Limits ±0.″002 (0.05 mm.)

FIG. 4.—Test Specimen for Dielectric Strength (Specimen No. 1).

on the bottom extending to within about $\frac{1}{8}$ in. of the edge. Whenever it is impossible to puncture the specimen in air without arcing over the edge, it shall be deeply immersed in high grade transformer oil. On specimens which require a very high voltage to puncture it may be necessary to put a glass tube or shield over the wire leading to the inside in order to prevent breakdown over the surface of the oil between terminals. The testing voltage shall be raised from zero at a constant rate of approximately 1000 volts per second until puncture occurs.

(*b*) Ten specimens shall be punctured in the condition received at normal room temperature of about 21° C. (70° F.) in order to determine the uniformity of the molded material.

Five specimens shall be punctured after heating for one hour in an oven heated to 10° C. (18° F.) below the softening point of the material as determined under Part (*C*), Sections 22 to 25. Puncture tests shall be made at this temperature with a permissible variation of ±5 per cent in degrees Centigrade. This test is intended to cover all molded materials which do not stand working temperatures above 125° C. (257° F.). Tests on materials which resist very high temperatures may be made above 125° C. (257° F.) when required.

Five specimens shall be punctured after they have had the rim immersed in melted paraffin for a depth of 1 in. and been entirely immersed in distilled water for 48 hours at normal room temperature of about 21° C. (70° F.). The surface of the specimen shall be wiped off with a dry cloth to remove all trace of excessive surface moisture and the puncture test shall be made in oil when necessary and at normal room temperature.

Report. 17. The results of tests shall be reported in the following order:

(*a*) The thickness of each specimen measured by micrometer in the direction perpendicular to its bottom surface, regardless of the path taken by the discharge. The thickness of all specimens shall be given in millimeters or mils.

(*b*) The puncture voltage of each test specimen and the average volts per millimeter or per mil as calculated from the average thickness of the specimens. Also give the maximum and minimum volts per millimeter or per mil.

(*c*) State the general character of the material tested with regard to leakage, if any is observed, and give the puncture voltage in volts per unit of thickness withstood by the bottom section whenever puncture takes place on the side of the specimen. This indicates the dielectric strength under both favorable and unfavorable conditions of molding. Experience shows that very plastic materials which flow easily when hot always puncture through the bottom, while materials which do not flow readily will often puncture through the side walls of a specimen at some distance up from the bottom.

(*d*) Report the frequency of the electrical circuit from which the test voltage is obtained.

(*C*) *Thermal.*

DISTORTION UNDER HEAT.

Specimen. 18. The same test specimen shall be used for this test as required for the transverse strength test, Section 10, molded from a hard steel mold ground to the dimensions given in Fig. 3.

Apparatus. 19. A special apparatus shall be used for this test as shown in Fig. 5. The specimen is supported on steel supports 100 mm. (3.94 in.) apart with the load applied on top of the specimen vertically and midway between the supports, the same as for the transverse test. The machine shall be arranged to apply two different loads, 2½ kg. (5.512 lb.) and 5 kg. (11.023 lb.). The specimen shall be placed in an air bath surrounded by an oil bath which is so arranged that its temperature may be raised gradually. The machine shall be so arranged that the deflection of the specimen at its center between the supports can be measured on a scale in millimeters or mils and shall be equipped with a thermometer so that the temperature of the specimen can be recorded at any time. The machine may be arranged to automatically shut off the heat and sound an alarm as soon as the required deflection is reached.

Method. 20. Three test specimens shall be tested in the condition in which they are received, starting at normal room temperature of 21° C. (70° F.) and increasing the temperature of the specimen gradually at the rate of approximately 1° C. every two minutes.

The distortion point shall be considered the temperature at which the specimen has deflected 0.254 mm. (10 mils) at the center between the supports.

Report. 21. The results of the test shall be reported in the following order:

(*a*) The distortion point in degrees Centigrade and also in degrees Fahrenheit;

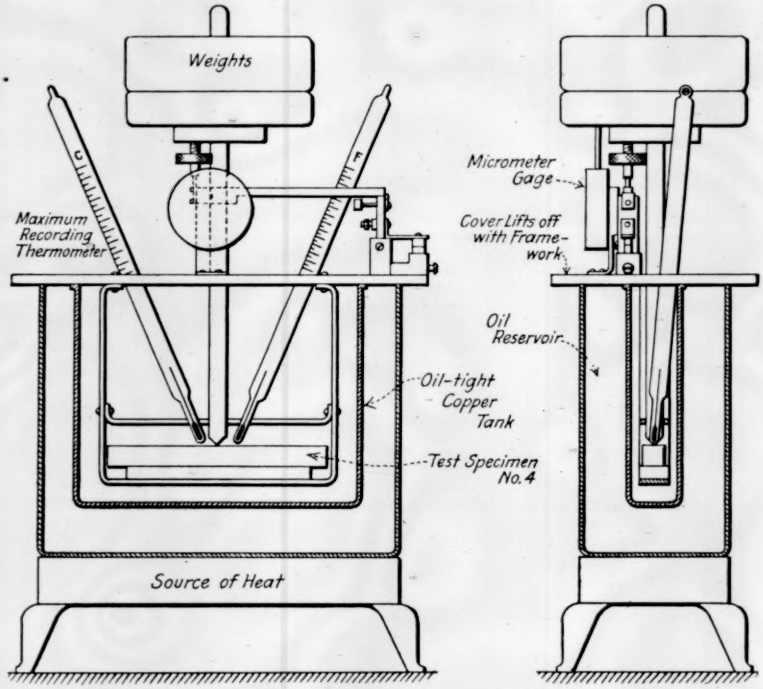

Weights
C
F
Maximum Recording Thermometer
Oil-tight Copper Tank
Test Specimen No. 4
Source of Heat
Micrometer Gage
Cover Lifts off with Frame-work
Oil Reservoir

FIG. 5.—Machine for Temperature Tests.

(*b*) The length of time required for the specimen to deflect 0.254 mm. (10 mils).

(*c*) State any peculiar characteristics of the material as noted either during the test or after the specimen is removed from the machine.

(*d*) Plot a curve for each test specimen showing the time

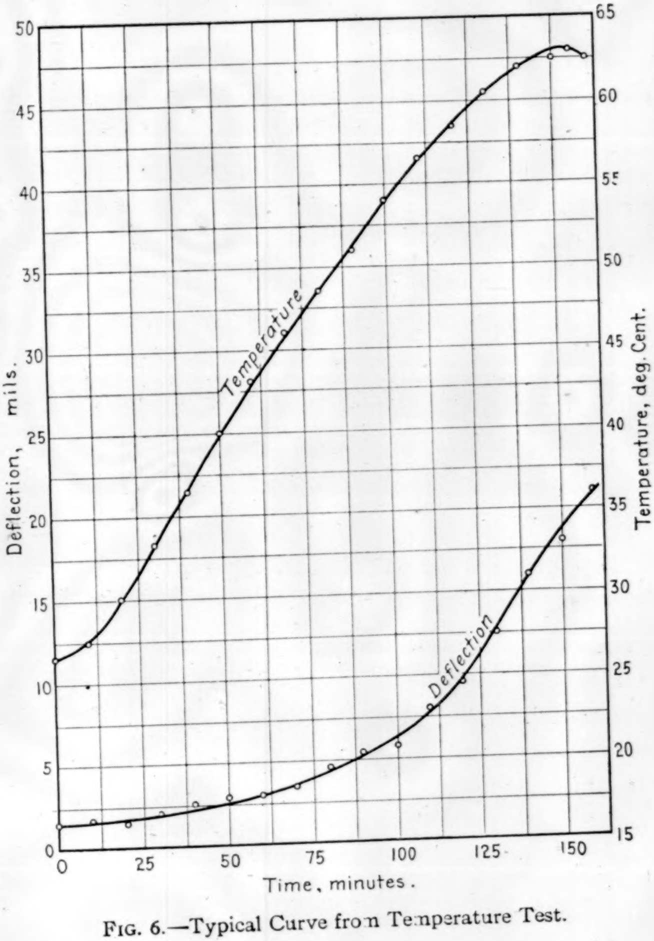


FIG. 6.—Typical Curve from Temperature Test.

in minutes horizontally and the amount of deflection and also the temperature at given intervals, using vertical ordinates as shown in Fig. 6.

(*D*) *Effect of Moisture.*

Specimen. 22. One-half of the standard test specimen shown in Fig. 1 shall be used for this test. This specimen shall be broken in half and all loose particles removed.

Apparatus. 23. Any good chemical balance may be used; also, a beaker of distilled water at normal room temperature of about 21° C. (70° F.), and an oven of any standard make, capable of maintaining a uniform temperature of 100° C. (212° F.), ± 5° C.

Method. 24. Weigh carefully three test specimens in the condition in which they are received. If the material softens readily at moderate temperatures, the specimens may be placed in a desiccator for 24 hours, or in an oven at a temperature of 50° C. (122° F.), ± 5° C., for 24 hours. For materials which do not soften readily the specimens shall be placed in an oven heated to 100° C. (212° F.), ± 5° C., for 24 hours. After drying, the specimens shall be weighed again at normal room temperature. Place the specimens in distilled water, wholly immersed, for 100 hours at normal room temperature. Remove the specimens at the end of 100 hours, wipe off all surface water with a dry cloth and weigh carefully.

Report. 25. The results of the test shall be reported in the following order:

(*a*) The original weight of each specimen;

(*b*) The dry weight of each specimen;

(*c*) The saturated weight in grams of each specimen after immersion for 100 hours;

(*d*) The percentage of moisture contained in each test specimen as received, and the percentage of moisture absorbed during 100 hours, taking the dry weight as 100 per cent. Give the average for the three specimens.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE TESTS
FOR
AUTOMOBILE TIRE FABRICS.[1]

Serial Designation: D 31 – 16 T.

These tests are issued under the fixed designation D 31; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

I. GENERAL REQUIREMENTS.

General Requirements.

1. Tests upon automobile tire fabrics shall be made in accordance with the Tentative General Methods for Testing Cotton Fabrics (D 39 – 16 T) of the American Society for Testing Materials,[2] with the modifications specified below.

II. SPECIAL REQUIREMENTS.

(*A*) *Number of Threads per Inch.*

Number of Threads per Inch.

2. (*a*) The number of threads per inch or count of the fabric shall be determined by counting a space of 10 in. in at least five different places in the roll.

(*b*) The average of the five determinations shall be the count.[3]

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[1] Criticisms of these Tentative Tests are solicited and should be directed, preferably before January 1, 1918, to Mr. G. B. Haven, Chairman of Committee D-13 on Textile Materials, Massachusetts Institute of Technology, Cambridge, Mass.

[2] See p. 829.

[3] A 10-in. steel "count scale" similar to an engineer's triangular scale, graduated with teeth one inch apart on one edge, and to the specifications of the cloth on the others,—for example, 23 teeth per inch on the second and 23 teeth per inch with each inch indicated on the third edge, as shown in Fig. 1 will be found convenient, rapid, and accurate for making this measurement when used in the manner of a machinist's thread gage. The chairman will furnish any information desired regarding this count scale.

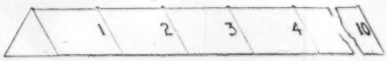

FIG. 1.

(*B*) *Strength.*

Strength. 3. (*a*) The strength of the fabric shall be determined by the "Strip Method."

(*b*) The test specimens shall be tested in the "dry condition" as defined in Section 2 of the Tentative General Methods D 39. They shall be taken one at a time from the drying oven and immediately securely clamped in the jaws of the machine, care being taken to see that the threads being tested are parallel to the direction of the pull and the cross threads are perpendicular to the line of pull.

(*c*) The breaking stress should be obtained within 30 seconds after taking a specimen from the oven.

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TENTATIVE TESTS FOR COTTON FABRICS FOR USE IN HOSE, BELTING AND SIMILAR ARTICLES.[1]

Serial Designation: D 32 – 16 T.

These tests are issued under the fixed designation D 32; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Issued, 1916.

I. GENERAL REQUIREMENTS.

General Requirements. 1. Tests upon fabrics for use in hose, belting and similar articles shall be made according to the Tentative General Methods for Testing Cotton Fabrics (D 39 – 16 T) of the American Society for Testing Materials,[2] with the modification specified below.

II. SPECIAL REQUIREMENTS.

Strength. 2. The strength shall be determined by the "Grab Method," and the specimens when tested shall be at "standard condition" as defined in Section 3 of the Tentative General Methods D 39.

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[1] Criticisms of these Tentative Tests are solicited and should be directed, preferably before January 1, 1918, to Mr. G. B. Haven, Chairman of Committee D-13 on Textile Materials, Massachusetts Institute of Technology, Cambridge, Mass.

[2] See p. 829.

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TENTATIVE TESTS
FOR
COTTON FABRICS FOR USE IN BAGS AND BAGGING MATERIAL.[1]

Serial Designation: D 33 – 16 T.

These tests are issued under the fixed designation D 33; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

I. GENERAL REQUIREMENTS.

General Requirements. 1. Tests upon fabrics for use in bags and bagging material shall be made according to the Tentative General Methods for Testing Cotton Fabrics (D 39–16 T) of the American Society for Testing Materials,[2] with the modifications specified below.

II. SPECIAL REQUIREMENTS.

(*A*) *Determination of Dimensions of Bags.*

Dimensions. 2. The dimensions of a bag shall be determined by turning it wrong side out, laying it smooth and flat without stretching and measuring with a stiff rule the distance between the seams, the seam and the crease, or between the creases, as the case may be.

(*B*) *Width of Cloth.*

Width. 3. The width of the cloth at any place shall be measured at right angles to the selvages when laid open on a flat horizontal surface and smoothed out by hand but not stretched.

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[1] Criticisms of these Tentative Tests are solicited and should be directed, preferably before January 1, 1918, to Mr. G. B. Haven, Chairman of Committee D-13 on Textile Materials, Massachusetts Institute of Technology, Cambridge, Mass.

[2] See p. 829.

(*C*) *Preparation of Test Specimens.*

Test Specimens. 4. Test pieces shall be cut approximately as shown in Fig. 1. For the strip method they shall be 8 in. long by 1½ in. wide and for the grab method 5 in. long by 2 in. wide.

(*D*) *Strength.*

Strength. 5. (*a*) The strength of the fabric shall be determined by the "Grab Method" or "Strip Method" as specified.

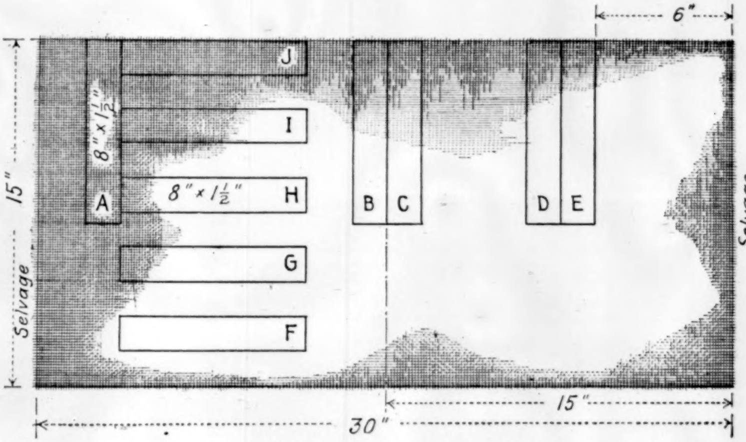

FIG. 1.—Location of Test Specimens.

(*b*) The test specimens shall be tested in the "dry condition" as defined in Section 2 of the Tentative General Methods D 39. They shall be taken one at a time from the drying oven and immediately securely clamped in the jaws of the machine, care being taken to see that the threads being tested are parallel to the direction of the pull and the cross threads are perpendicular to the line of pull.

(*c*) The breaking stress should be obtained within 30 seconds after taking a specimen from the oven.

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TENTATIVE METHODS
FOR
ROUTINE ANALYSIS OF DRY RED LEAD[1]

Serial Designation: D 49 - 17 T.

These methods are issued under the fixed designation D 49; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

1. The approximate formula of Red Lead is Pb_3O_4 (probably $PbO_2.2PbO$).

SPECIFIC GRAVITY.

Specific Gravity. 2. True specific gravity shall be determined by Thompson's method,[2] or by means of a 50-cc. pyknometer, using c.p. benzine and 20 g. of pigment.

MOISTURE.

Moisture. 3. Dry 2 g. of the sample for 2 hours at 105° C. The loss in weight is considered as moisture.

ORGANIC COLOR.

Organic Color. 4. Boil 2 g. of the sample with 25 cc. of 95-per-cent ethyl alcohol, let settle, decant off the supernatant liquid; boil residue with water, decant as before and boil residue with very dilute NH_4OH. If either the alcohol, water or NH_4OH is colored, organic coloring matter is indicated.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1918, to Mr. G. W. Thompson, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIII, p. 407 (1913).

TOTAL LEAD AND INSOLUBLE MATTER.

Total Lead and Insoluble Matter.

5. Treat 1 g. of the sample with 15 cc. of HNO_3 (1 : 1) and sufficient H_2O_2 to dissolve all PbO_2 on warming. If any insoluble matter is present, add 25 cc. of water, boil, filter and wash with hot water. The insoluble matter contains free SiO_2 and should be examined for $BaSO_4$ and silicates, if appreciable. To the original solution or filtrate from insoluble, add 20 cc. of concentrated H_2SO_4 and evaporate to SO_3 fumes; cool, add 150 cc. of water and 150 cc. of 95-per-cent ethyl alcohol, let stand *cold* 2 hours, filter on a Gooch crucible, wash with 95-per-cent alcohol, dry at 105 to 110° C. and weigh as $PbSO_4$. Calculate to PbO. Red lead is rarely adulterated, but should sample contain soluble barium compounds, the $PbSO_4$ obtained above will contain $BaSO_4$. In this case, digest above precipitate with acid ammonium-acetate solution, filter off $BaSO_4$, wash, ignite and weigh $BaSO_4$. Calculate to BaO or $BaCO_3$. In filtrate, determine the lead as $PbSO_4$ or $PbCrO_4$. If sample contains significant amounts of calcium or magnesium, the HNO_3–H_2O_2 solution is boiled till all lead is converted into nitrate and then the lead is determined as $PbCrO_4$.

If calcium and magnesium are to be determined, proceed as follows: Precipitate the lead as sulfide from a slightly acid (HCl) solution, dissolve the PbS in hot dilute HNO_3 and determine the lead as sulfate. Boil the filtrates from the PbS to expel H_2S, add a little bromine water to oxidize iron (if present), boil to expel bromine, and then add NH_4OH in slight excess. Filter off any precipitate of $Fe(OH)_3+Al(OH)_3$; wash with hot water. (If appreciable, redissolve in hot dilute HCl and reprecipitate with NH_4OH, ignite and weigh $Fe_2O_3+Al_2O_3$.) Manganese, if present, can be precipitated by adding bromine and NH_4OH and warming; filter, wash with hot water, ignite and weigh as Mn_3O_4. Unite all of the filtrates, make slightly acid with acetic acid, heat to boiling and pass H_2S into the hot solution till saturated (20 to 30 minutes); add 5 g. of NH_4Cl and let stand 5 hours; filter off any ZnS, wash with H_2S water, dissolve the ZnS in hot dilute HCl and determine the zinc by titration with $K_4Fe(CN)_6$. Or, boil off the H_2S, filter out any separated sulfur and determine the zinc as $Zn_2P_2O_7$. Calcium may be determined in the filtrate from the ZnS by expelling H_2S and then adding NH_4OH and ammonium oxalate in the usual manner. Titrate with $KMnO_4$. In the filtrate from calcium determine magnesium in the usual manner by precipitating with sodium-phosphate solution, finally weighing as $Mg_2P_2O_7$.

LEAD PEROXIDE (PbO_2) AND TRUE RED LEAD (Pb_3O_4).

(Method of Diehl[1] modified by Topf[2]—not applicable when substances are present, other than oxides of lead, that liberate iodine under conditions given.)

Lead Peroxide and True Red Lead.

6. Weigh 1 g. of finely ground sample into a 200-cc. Erlenmeyer flask, add a few drops of distilled water and rub the mixture to a smooth paste with a glass rod flattened on end. Mix in a small beaker 30 g. of c. p. "Tested Purity" crystallized sodium acetate, 2.4 g. of c. p. KI, 10 cc. of water and 10 cc. of 50-per-cent acetic acid; stir until all is liquid, warming gently; if necessary add 2 to 3 cc. of water, cool to room temperature and pour into the flask containing the red lead. Rub with the glass rod until nearly all the red lead has been dissolved; add 30 cc. of water containing 5 or 6 g. of sodium acetate, and titrate at once with decinormal sodium thiosulfate, adding the latter rather slowly and keeping the liquid constantly in motion by whirling the flask. When the solution has become light yellow, rub any undissolved particles up with the rod until free iodine no longer forms, wash off rod, add the sodium-thiosulfate solution until *pale yellow*, add starch solution and titrate until colorless, add decinormal iodine solution until blue color is just restored and subtract the amount used from the volume of sodium thiosulfate that had been added.

Calculation.—The iodine value of the sodium-thiosulfate solution multiplied by $0.94193 = PbO_2$; the iodine value multiplied by $2.69973 = Pb_3O_4$; the PbO_2 value multiplied by $2.86616 = Pb_3O_4$.

The sodium-thiosulfate solution and the starch solution shall be prepared as follows:

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[1] *Dingl. polyt. Jour.*, Vol. 246, p. 196.

[2] *Zeitschrift für analytische Chemie*, Vol. 26, p. 296.

Sodium-Thiosulfate Solution (decinormal).—Dissolve 24.83 g. of c. p. sodium thiosulfate, freshly pulverized and dried between filter paper, and dilute with water to 1 liter at the temperature at which the titrations are to be made. The solution is best made with well-boiled water free from CO_2, or let stand 8 to 14 days before standardizing. Standardize with pure, re-sublimed iodine, as described in Treadwell-Hall, "Analytical Chemistry," Vol. II, p. 602 (1910), and also against pure potassium iodate; the two methods of standardization should agree within 0.1 per cent on iodine value.

Starch Solution.—Stir up 2 to 3 g. of potato starch with 100 cc. of 1-per-cent salicylic-acid solution, and boil the mixture till starch is practically dissolved, then dilute to 1 liter,[1] or as per Lord.[2]

DETERMINATION OF ZINC.

Zinc.

7. If in appreciable amount, evaporate off the alcohol from the filtrate from total lead, make alkaline with NH_4OH, then acid with HCl, add 3 cc. more of concentrated HCl, dilute to about 250 cc. with water, heat nearly to boiling and titrate with standard $K_2Fe(CN)_6$ solution as described by Low.[3] Report as ZnO (includes cadium). Iron, copper or other interfering substances should first be removed as described by Low.

WATER-SOLUBLE.

Water-Soluble.

8. Digest 10 g. of sample with 200 cc. of hot water on steam bath for 1 hour; filter on an 11-cm. S. & S. blue-ribbon paper and wash with hot water till no residue is left on evaporating a few drops of the washings. Evaporate filtrate to dryness on steam bath in a weighed dish, dry 30 minutes at 105° C., cool and weigh. Take up with water and if alkaline, titrate with tenth normal acid and methyl orange; calculate to Na_2CO_3.

Another lot of water-soluble matter is tested for nitrates, nitrites, carbonates, sulfates, sodium and lead.

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[1] *Lead Peroxide.*—If sample contains an appreciable amount of nitrite (nitrate has no effect on method), leach out water-soluble matter as below, dry residue and determine PbO_2 as above, calculating to basis of original sample.

[2] "Notes on Metallurgical Analysis," p. 103 (1903).

[3] Low, "Technical Methods of Ore Analysis."

TOTAL SILICA.

Total Silica.

9. Digest 5 g. of the sample in a covered casserole with 5 cc. of HCl and 15 cc. of HNO_3 (1 : 1). Evaporate to dryness to dehydrate. Cool, treat with hot water and HNO_3, boil, filter, wash with hot acid ammonium-acetate solution, then dilute HCl and finally hot water. Ignite and weigh as SiO_2. The residue may be treated with H_2SO_4 and HF in cases of doubt as to purity.

CARBON DIOXIDE.

Carbon Dioxide.

10. Determine carbon dioxide by the evolution method, using dilute HCl and stannous chloride.

DETERMINATION OF SOLUBLE SULFATE.

Soluble Sulfate.

11. *Sulfates other than Barium Sulfate.*—Treat 0.5 g. of the sample with 5 cc. of water, 3 g. of NH_4Cl and 5 cc. of HCl saturated with bromine; digest (covered) on steam bath about 15 minutes, add 25 cc. of water, neutralize with dry Na_2CO_3, and add about 2 g. more, boil 10 to 15 minutes; let settle, dilute with hot water, filter and wash with hot water; redissolve in HCl, reprecipitate as above and wash thoroughly with hot water; acidify united filtrates with HCl, adding a slight excess; boil and add slight excess of 10-per-cent $BaCl_2$ solution. Let stand on steam bath 1 hour, filter, wash with hot water, ignite, and weigh $BaSO_4$. Calculate to SO_3 (includes SO_3 formed from SO_2).

Or, dissolve 0.5 g. of the sample in 25 cc. of water, 10 cc. of NH_4OH (sp. gr. 0.90) and HCl in slight excess; dilute to about 150 cc. with water and add a piece of aluminum foil which should about cover the bottom of the beaker—this held on bottom by means of a stirring rod. Heat gently till all lead is precipitated, decant through a filter, pressing the lead sponge with a flattened rod, and washing with hot water. Add to the filtrate a little pure bromine water, boil until bromine is expelled, add 15 cc. of 10-per-cent $BaCl_2$ solution, let stand on steam bath one hour, filter, wash with hot water, ignite and weigh as $BaSO_4$ (any $SrSO_4$ present is not decomposed in this method).[1]

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[1] The solubility of $BaSO_4$ is increased by the presence of aluminum chloride. See J. W. Mellor, "A Treatise on Quantitative Inorganic Analysis," p. 615.

IRON OXIDE.

Iron Oxide. 12. Determine iron oxide by Schaeffer's[1] modification of Thomson's colorimetric method; or, in a large beaker, treat 20 g. of the sample with 20 cc. of water, 20 cc. of HNO_3 (sp. gr. 1.4) and 3 cc. of formaldehyde solution. Warm till all PbO_2 is dissolved, dilute with water, warm, filter off insoluble and wash with hot water. Ignite filter and insoluble, evaporate with H_2SO_4 and HF. To filtrate from insoluble add 14 cc. of H_2SO_4 (1 : 1), filter off $PbSO_4$, and wash. Dissolve residue from HF and H_2SO_4 in H_2SO_4 and add to filtrate from $PbSO_4$; dilute to 500 cc. and determine iron colorimetrically in an aliquot, using same amounts of HNO_3, H_2SO_4 and formaldehyde in comparison solution.[2] Calculate to Fe_2O_3.

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[1] *Journal of Industrial and Engineering Chemistry*, Vol. 4, p. 659 (1912).

[2] Lunge-Berl, "Chemisch-technische Untersuchungs-Methoden," Bd. 2, S. 95, 6th Ed.

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TENTATIVE METHODS
FOR
ROUTINE ANALYSIS OF YELLOW, ORANGE, RED, AND BROWN PIGMENTS CONTAINING IRON AND MANGANESE.[1]

Serial Designation: D 50 – 17 T.

These methods are issued under the fixed designation D 50; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

GENERAL METHODS.

SPECIFIC GRAVITY.

Specific Gravity.

1. True specific gravity shall be determined by Thompson's method,[2] or by means of a 50-cc. pyknometer, using c. p. benzine and 10 to 20 g. of pigment.

TINTING STRENGTH.[3]

Tinting Strength.

2. The colors should always be compared with a carefully selected standard. Weigh out accurately from 0.02 to 0.05 g. of color, place on a large glass plate, add 12 drops of bleached linseed oil,[4] and rub up with a flat-bottom glass pestle or muller;

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1918, to Mr. G. W. Thompson, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIII, p. 407 (1913).

[3] Holley, "Analysis of Paint and Varnish Products," 1912, p. 126.

[4] The use of "oxidized" oil should be avoided (oil that has become "fatty" by standing around in a can or bottle). Poppy-oil could be used but it is quite as necessary to have it reasonably fresh as when linseed oil is used. In either case "stringy" pastes are not reliable.

then add 1 g. of pure ZnO, and grind with a circular motion 50 times; gather up with a sharp-edge spatula and grind out twice more in like manner, giving the pestle a uniform pressure. Next weigh out a similar amount of the standard, and treat in exactly the same manner as described above. Transfer portions of each paste to a microscope slide, quite close together, and then draw a palette knife across both samples so as to make them meet in a line (differences in tint are then easily seen). Compare the tints as shown on both sides of the glass. The amount of pigment used will vary with the tinting strength, but generally it suffices to take about 0.02 g. of the reds and about 0.05 g. of the ochers.

If it is desired to express quantitatively the tinting strength of the pigment, consider the standard pigment as having a tinting strength of 100, and then vary the amount of the standard pigment until the tints are matched.

For example, let the amount of standard pigment for 100 strength test be 0.02 g. ($= A$). Vary this amount in units of 5 per cent, thus 0.019 or 0.021. Let the amount taken to match a given strength $= B$, then

$$\frac{B}{A} \times 100$$

equals the tinting strength of the sample to be tested.

If the tone varies it may be difficult to make this measurement.

ADDED COLORING MATTER.

Added Coloring Matter.

3. Test the pigment successively with hot water, 95-per-cent ethyl alcohol, alcoholic NaOH or KOH and acetic acid. Chloroform, NaOH, H_2SO_4, HCl-stannous chloride, and other reagents may be tried.[1] The presence of an organic color may often be noted by the characteristic odor given off on ignition.

METHODS FOR ANALYSIS OF INDIAN REDS, RED OXIDES (PRINCE'S METALLIC, TUSCAN RED).

LOSS AT 100° C.

Loss at 100° C.

4. Heat 2 g. in a steam-jacketed oven at atmospheric pressure for three hours, or to constant weight.

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[1] For details consult Zerr, "Tests for Coal-Tar Colors in Aniline Lakes," (English translation by C. Mayer); Schultz and Julius, "A Systematic Survey of the Organic Coloring Matters;" Hall, "The Chemistry of Paints and Paint Vehicles;" and Mulliken, "Identification of Pure Organic Compounds," *Commercial Dyestuffs*, Vol. III.

LOSS ON IGNITION.

Loss on Ignition.

5. Ignite a portion in a covered porcelain crucible to constant weight. This may include combined water, CO_2, organic matter, and some SO_3 if much $CaSO_4$ is present. CO_2 may be determined on a separate portion of the sample if desired.[1]

FREE ACID OR ALKALI.

Free Acid or Alkali.

6. Boil 10 g. of sample with 100 cc. of water; filter and wash. Test filtrate with litmus paper; if acid, titrate with standard alkali and methyl orange and calculate to the equivalent of H_2SO_4. If alkaline, titrate with acid and calculate to the equivalent of Na_2O. Test filtrate for alkali salts and alkaline earths.

ADDED COLORING MATTER.

Added Coloring Matter.

7. Test as under "General Methods."

INSOLUBLE, IRON OXIDE, ETC.

Insoluble, Iron Oxide, etc.

8. Digest 2.5 g. of the sample (previously roasted at a low temperature if much organic matter is present; if very low in carbonaceous matter a little $KClO_3$ or $NaClO_3$ may be used in effecting solution) with 25 cc. of HCl (adding a little HNO_3 or chlorate, if not already added), wash off cover, and evaporate to dryness. Take up with HCl and water, filter, wash with dilute HCl and cold water. Make the filtrate up to 500 cc., mix, and examine as below.[2] Ignite the residue and weigh as "insoluble matter";[3] if this contains $BaSO_4$ it may be determined by fusing with six times its weight of Na_2CO_3, cooling, digesting with hot water, filtering, and washing the residue with hot water until free of sulfate.

Remove filtrate and place beaker used for the digestion underneath the funnel, pierce the filter with the glass rod, and wash the residue with a little water into the beaker; then pour hot dilute HCl (1 : 1) over paper, and finally wash with hot water. If necessary add more HCl to the beaker to dissolve the $BaCO_3$; heat to boiling, add dilute H_2SO_4 in slight excess, let stand about one hour on steam bath; filter, wash, dry, ignite, and weigh $BaSO_4$. (This subtracted from total insoluble will give "insoluble silicious matter," if it is desired to so report.) If it is desirable to analyze the insoluble silicious matter, this can be done by the usual methods for silicate analysis, but the results should be reported as a separate analysis.

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[1] It is inadvisable to use platinum unless it is known that attacking substances are absent.

[2] For more exact work this filtrate should be evaporated to dryness and SiO_2 removed.

[3] If the insoluble contains appreciable amounts of Fe it will be necessary to fuse it with Na_2CO_3 or $K_2S_2O_7$ to determine total Fe in samples.

For the determination of iron place 100 cc. of the first filtrate in a flask, add about 3 g. of granulated zinc, put a funnel into the neck of the flask, heat when the action slackens; if basic salts separate out add a few drops of HCl. When the reduction is complete, add 30 cc. of H_2SO_4 (1 : 2), and as soon as the residual zinc is dissolved, wash down the funnel inside and out and the neck of the flask with a fine jet of water, filling the flask (1000 cc.) about two-thirds full, cool in water, add 10 cc. of "titrating solution" (made by dissolving 160 g. of manganese sulfate in water, diluting to 1750 cc., adding 330 cc. of H_3PO_4, sp. gr. 1.72, and 320 cc. of concentrated H_2SO_4), and titrate with $KMnO_4$ (5.659 g. per liter) that has been standardized against Bureau of Standards sodium oxalate. Run a blank on the zinc, correct for same and calculate total iron as Fe_2O_3. Instead of adding the zinc to the solution, the reduction may be effected in a zinc reductor.[1]

The Fe_2O_3 may also be determined by the $K_2Cr_2O_7$ method.[2]

LIME.

9. Dilute an aliquot of 100 cc. of the original solution to about 200 cc., add 10 cc. of HCl, make alkaline with HN_4OH, add 2 or 3 cc. of bromine water, and boil till excess of NH_3 is expelled. Let settle, wash by decantation, redissolve in HCl, and reprecipitate with NH_4OH and bromine water. (Precipitate = $Fe_2O_3 . Al_2O_3 . TiO_2 . P_2O_5 . MnO_2$.) This precipitate may be ignited and weighed if desired. **Lime.**

To the combined filtrates add a few drops of NH_4OH, heat to boiling, and add an excess of saturated ammonium-oxalate solution; continue the boiling until the precipitate becomes granular, let stand about 30 minutes, filter, and wash with hot water till free of ammonium oxalate;[1] place beaker in which precipitation was made under the funnel, pierce apex of filter with stirring rod and wash precipitate into beaker with hot water, pour warm dilute H_2SO_4 (1 : 4) through paper and wash a few times; add about 30 cc. of H_2SO_4 (1 : 4), dilute to about 250 cc., heat to 90° C. and titrate at once with standard $KMnO_4$ solution (solution should not be below 60° C. when end-point is reached). Calculate to CaO. (The Fe value of $KMnO_4 \times 0.502 = CaO$.) The calcium-oxalate precipitate may be ignited to constant weight as CaO. If desired, magnesia may be determined as $Mg_2P_2O_7$ in the usual manner in the filtrate from the calcium oxalate.[2]

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[1] Lord and Demorest, "Metallurgical Analysis," 1913, pp. 28–29.

[2] *Ibid.*, pp. 21–26.

SOLUBLE SULFATES.

Soluble Sulfates.

10. Treat 1 g.[3] of the pigment (roasted gently if much organic matter is present) with 30 cc. of HCl, boil 10 minutes, add about 50 cc. of water, boil, filter, and wash with hot water. Heat the solution to boiling, add NH_4OH, filter and wash a few times with hot water; dissolve precipitate in hot dilute HCl and reprecipitate with NH_4OH, wash well with hot water. Render united filtrates just distinctly acid with HCl, boil, add by drops with stirring excess of 10-per-cent $BaCl_2$ solution, boil about 10 minutes, filter on a Gooch crucible, wash with hot water, ignite and weigh as $BaSO_4$. Calculate to SO_3 or $CaSO_4$.

TOTAL SULFUR OTHER THAN THAT PRESENT AS $BaSO_4$.

Total Sulfur.

11. Treat 5 g. of the sample in a covered porcelain dish with 50 cc. of aqua regia (1 HNO_3 : 9 HCl) and evaporate to dryness on steam bath. Add 20 cc. of concentrated HCl and about 250 cc. of water, make double NH_4OH precipitation; determine $BaSO_4$ as given under "Soluble Sulfates."

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[1] For more exact work this precipitate should be dissolved in HCl and the calcium oxalate reprecipitated as above.

[2] If desired, a direct determination of Al_2O_3 may be made on an aliquot of the solution or on the HCl solution of the NH_4OH precipitate by Peters' phosphate method (this will include titanic acid) as described by Blair, "The Chemical Analysis of Iron," and Philips, "Methods of Iron Analysis Used in the Pittsburgh District."

[3] If low in soluble sulfates use a larger portion of sample.

METHODS FOR ANALYSIS OF OCHERS.

12. Loss at 100° C., loss on ignition, insoluble matter, total or soluble iron, alumina, lime and sulfur may be determined as outlined under the "Methods for Analysis of Indian Reds, etc.," using 1 g. or an aliquot corresponding to this weight.

TINTING STRENGTH.

Tinting Strength.

13. Test as under "General Methods." Tests should be made for solubility in water, and reaction to litmus paper.

LEAD CHROMATE.

Lead Chromate.

14. If present, the lead is removed in the above scheme by nearly neutralizing the filtrate from the insoluble matter with NH_4OH, cooling, and passing in H_2S, to precipitate PbS. Filter, wash with water containing H_2S, dissolve PbS in hot dilute HNO_3, add 10 cc. of concentrated H_2SO_4, evaporate till SO_3 is evolved, cool, dilute to 200 cc., let stand a few hours, filter on a Gooch crucible, wash with 1-per-cent H_2SO_4, ignite, and weigh $PbSO_4$. Calculate to PbO or Pb. Heat the filtrate from the PbS to expel H_2S, oxidize with a little HNO_3, and make up to volume if working on more than 1 g.

The iron is best determined in an aliquot by the $K_2Cr_2O_7$ method. Another aliquot is treated with NH_4OH, the precipitate containing $Al_2O_3.Fe_2O_3.Cr_2O_3.P_2O_5.TiO_2$. Lime and MgO may be determined in filtrate.

The NH_4OH precipitate is dissolved in hot dilute HCl, washing paper with hot water, *cooled*, oxidized with Na_2O_2, boiled to expel H_2O_2, cooled, cover glass washed off, diluted to about 150 cc., and acidified with H_2SO_4. Add a measured excess of ferrous ammonium-sulfate solution—$(NH_4)_2Fe(SO_4)_2.6H_2O$, 12.4 g.; concentrated H_2SO_4, 50 cc.; and water to make 1 liter, and titrate back with standard $K_2Cr_2O_7$ solution, using $K_3Fe(CN)_6$ solution as an outside indicator. The $(NH_4)_2Fe(SO_4)_2.6H_2O$ solution is titrated with the $K_2Cr_2O_7$ solution to determine its value in terms of the latter. The Fe value of the $K_2Cr_2O_7$ solution $\times 0.5969 = CrO_3$.

Or, moisten 1 g. of the pigment with water, add 5 cc. of concentrated HCl, boil a few minutes, *cool*, add Na_2O_2 in excess, boil to expel H_2O_2, cool, wash off cover glass, dilute, acidify with H_2SO_4, and titrate CrO_3 as above.

VENETIAN RED.

Venetian Red.

15. Analyze as given under "Methods for Analysis of Indian Reds, etc." Insoluble matter may be treated with HF and H_2SO_4 to determine SiO_2 by loss if desired.

METHODS FOR ANALYSIS OF SIENNAS AND UMBERS.

16. After gently roasting to destroy organic matter, test as given under "Methods for Analysis of Indian Reds, etc."

MANGANESE.

Manganese.

17. Manganese is determined by the bismuthate method.[1] Ignite gently (to destroy organic matter) 1 g. of the sample in a platinum dish, cool, add 10 cc. of water, 4 cc. of concentrated H_2SO_4 and about 20 cc. of HF (if necessary, add a little sulfurous acid). Evaporate until the H_2SO_4 fumes freely, cool and dissolve in 25 cc. of HNO_3 (1 part concentrated HNO_3 to 3 parts water). If no appreciable residue remains, transfer to a 100-cc. volumetric flask, using 25 cc. of HNO_3 (1 : 3) to rinse the dish, dilute to the mark with water, mix thoroughly. If there is an appreciable residue, filter on a small filter, wash with water, ignite residue in a platinum crucible, and fuse with a little sodium or potassium pyrosulfate. Dissolve in water, with the addition of a little HNO_3, add to the main filtrate, evaporate nearly to dryness, take up in HNO_3 (1 : 3) and transfer to the flask as before. Pipette an aliquot of 10 cc. into a 200-cc. Erlenmeyer flask, add 30 cc. of water and 10 cc. of concentrated HNO_3, sp. gr. 1.4; add about 0.5 g. of sodium bismuthate, heat for a few minutes, or until the pink color has disappeared with or without the precipitation of MnO_2. Add a few small crystals of sodium or potassium nitrite to dissolve the MnO_2 and boil the solution several minutes to expel nitrous fumes (a little Na_2CO_3 will aid this). Add water to bring the volume up to 50 cc. and cool to about 15° C.; add about 0.5 g. of bismuthate and shake the flask well. Add 50 cc. of water containing 30 cc. of concentrated HNO_3 to the liter, filter by suction through an asbestos felt into a 300-cc. Erlenmeyer flask

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[1] Blair, "The Chemical Analysis of Iron."

and wash with 50 to 100 cc. of the same acid. Run in a measured volume of standard ferrous ammonium-sulfate solution and titrate to a faint pink color with standard $KMnO_4$ solution. The number of cubic centimeters of the $KMnO_4$ solution obtained, subtracted from the number corresponding to the volume of ferrous solution used, will give the volume of $KMnO_4$ equivalent to the manganese in the sample, which, multiplied by the value of the $KMnO_4$ in Mn, gives the weight of manganese in the portion of sample used.

Standard $KMnO_4$ Solution.—The solution of $KMnO_4$ is composed of 1 g. dissolved in a liter of water. The Fe value of this solution × 0.1968 = Mn. This solution may be standardized against Bureau of Standards sodium oxalate (using about 0.05 to 0.1 g.)[1] Weight of $Na_2C_2O_4 \times 0.1639$ = Mn. Twelve grams of $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$, 25 cc. of concentrated H_2SO_4, and 25 cc. of H_3PO_4, sp. gr. about 1.7, are made up to 1 liter with water. The value of this solution should be determined against the $KMnO_4$ each day as follows:

Measure into a 200-cc. Erlenmeyer flask 50 cc. of HNO_3 (1 : 3), cool, add a little bismuthate, dilute with 50 cc. of 3-per-cent HNO_3, filter by suction through an asbestos felt into a 300-cc. Erlenmeyer flask, and wash with 50-cc. of 3-per-cent HNO_3. Run in 25 cc. of the ferrous solution and titrate with $KMnO_4$ solution. Instead of titrating the permanganic acid formed by the bismuthate with the ferrous solution and then titrating back with $KMnO_4$, a direct titration with standard sodium arsenite solution may be made.[2]

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[1] W. Blum, "Original Communications," Eighth International Congress of Applied Chemistry," Vol. I, pp. 61-85.

[2] Lord and Demorest, "Metallurgical Analysis," 1913, p. 82.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE FORM
OF
SPECIFICATIONS FOR CERTAIN COMMERCIAL GRADES OF BROKEN STONE.[1]

Serial Designation: D 35 – 16 T.

This form of specifications is issued under the fixed designation D 35; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

The broken stone shall consist of one product of the operation of a stone-crushing and screening plant without recombining or mixing, and shall conform to the following mechanical analysis using laboratory screens:

Passing screen having smallest holes selected	From .. to ..	per cent
Passing screen having next to largest holes selected	From .. to ..	"
Passing screen having largest holes selected	From .. to ..	"
Total passing screen having largest holes selected	100	"

Example.—The broken stone shall consist of one product of the operation of a stone-crushing and screening plant without recombining or mixing, and shall conform to the following mechanical analysis using laboratory screens:

Passing ¼-in. screen	3 to 10	per cent
Passing 1-in. screen and retained on ¼-in. screen	80 to 95	"
Passing 1¼-in. screen and retained on 1-in. screen	2 to 10	"
Total passing 1¼-in. screen	100	"

or the analysis may be expressed as follows:

Total passing ¼-in. screen	3 to 10	per cent
Total passing 1-in. "	90 to 98	"
Total passing 1¼-in. "	100	"

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[1] Criticisms of this Form of Specifications are solicited and should be directed, preferably before January 1, 1918, to Mr. L. W. Page, Chairman of Committee D-4 on Road Materials, U. S. Office of Public Roads and Rural Engineering, Washington, D. C.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHOD
FOR
DETERMINATION OF SOFTENING POINT OF BITUMINOUS MATERIALS OTHER THAN TAR PRODUCTS.[1]

Serial Designation: D 36 – 16 T.

This method is issued under the fixed designation D 36; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Definition. 1. The Ring-and-Ball method shall be used.

Apparatus. 2. The apparatus shall consist of a brass ring 15.875 mm. ($\frac{5}{8}$ in.) in diameter, 6.35 mm. ($\frac{1}{4}$ in.) deep, 2.38125 mm. ($\frac{3}{32}$ in.) wall, suspended 25.40 mm. (1 in.) above bottom of beaker; a steel ball 9:525 mm. ($\frac{3}{8}$ in.) in diameter, weighing between 3.45 and 3.50 g.; a standardized thermometer; a glass beaker, approximately 600-cc. capacity. (See Fig. 1.)

Method. 3. Carefully melt the sample and fill the ring with the material to be tested. Remove any excess. Place the ball in the center of the ring and suspend in the beaker containing approximately 400 cc. of water at a temperature of 5° C. (41° F.). Arrange the thermometer bulb within $\frac{1}{2}$ in. of the sample and at the same level. Apply heat *uniformly* over bottom of the beaker in quantity sufficient to raise the temperature 5° C. (9° F.) per minute. Record the temperature at starting the test and every minute thereafter until the test is completed. The rate of heating is very important. The softening point is the temperature at which the specimen has dropped 1 in. Successive tests should average within 3° C. For temperatures above 9° C., glycerin shall be used instead of water.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1918, to Mr. L. W. Page, Chairman of Committee D-4 on Road Materials, U. S. Office of Public Roads and Rural Engineering, Washington, D. C.

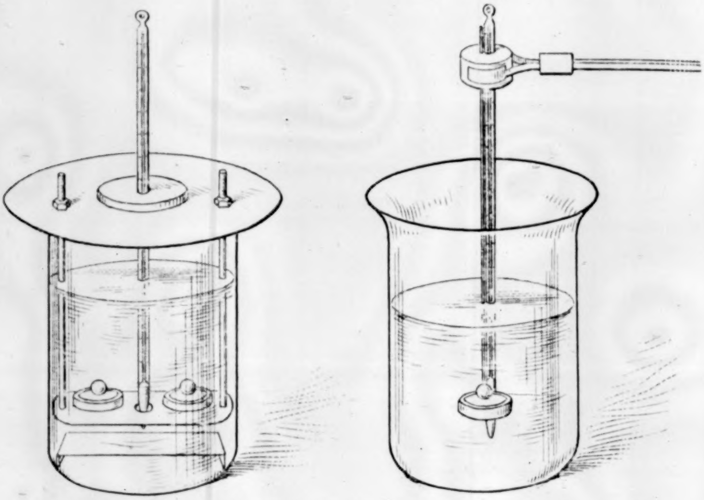

FIG. 1.—Apparatus for Determination of Softening Point.

AMERICAN SOCIETY FOR TESTING MATERIALS
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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS FOR LABORATORY SAMPLING AND ANALYSIS OF COKE.[1]

Serial Designation: D 37 – 16 T.

These methods are issued under the fixed designation D 37; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

DETERMINATION OF TOTAL MOISTURE AND PREPARATION OF LABORATORY SAMPLES.

APPARATUS.

Galvanized-Iron Pans 24 by 24 by 4 in. Deep.—For total moisture determination.

Balance or Solution Scale.—For weighing the galvanized-iron pans with samples. It should have a capacity of 10 kg. and be sensitive to 1 g.

Jaw Crusher.—For crushing coarse samples to pass a 4 mesh sieve.

Roll Crusher.—For reducing the 4-mesh product to 10-mesh.

Abbé Ball Mill or Hard-Steel Diamond Mortar.—For reducing the 10-mesh product to 60-mesh. The porcelain jars for the ball mill should be approximately 9 in. in diameter and 10 in. high. The flint pebbles should be smooth, hard and well rounded.

A Large Riffle Sampler, with $\frac{5}{8}$ or $\frac{3}{4}$-in. Divisions.—For reducing the 4-mesh sample to 5 lb. (Fig. 1).

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1918, to Mr. A. C. Fieldner, Secretary of Committee D-6 on Coke, Bureau of Mines, Pittsburgh, Pa.

A Small Riffle Sampler, with $\frac{1}{4}$ or $\frac{3}{8}$-in. Divisions.—For dividing down the 10 and 60-mesh material to a laboratory sample.

An 8-in. 60-mesh Sieve with Cover and Receiver.

Containers for Shipment to Laboratory.—Samples in which the moisture content is important should always be shipped in moisture-tight containers. A galvanized-iron or tin can with air-tight friction top or a screw top which is sealed with a rubber gasket and adhesive tape is best adapted to this purpose. Glass fruit jars sealed with rubber gaskets may be used, but require very careful packing to avoid breakage in transit. Samples in which the moisture content is of no importance need no special protection from loss of moisture.

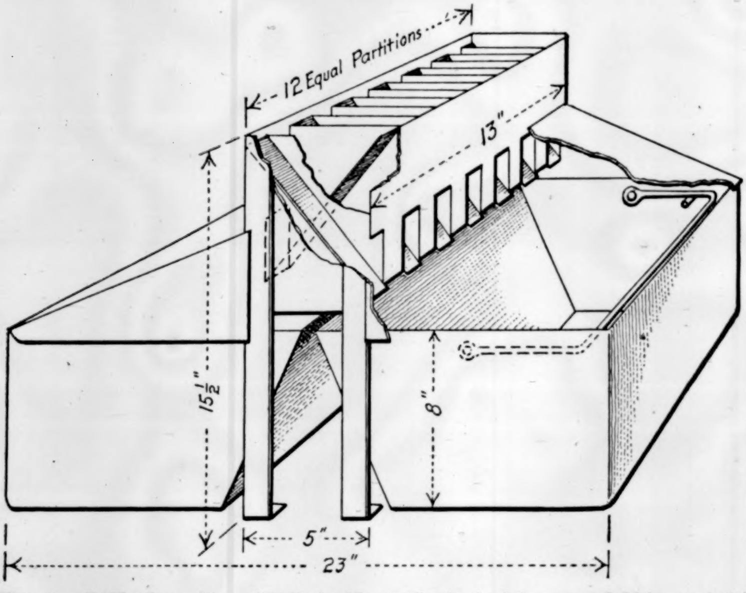

FIG. 1.—Riffle Sampler. (*Bulletin No. 9*, Geological Survey of Ohio, p. 213.)

Oven, Stove or Hot Plate.—For drying coke samples in the determination of total moisture. If an oven is used it should have openings provided for natural ventilation and should be capable of being regulated between 104 and 200° C. If the coke is dried on a stove or hot plate a thermometer should be placed in it, and care exercised that the temperature does not exceed 200° C. at any point in the pan of coke.

METHOD.

Total Moisture Determination.—Dry the entire sample received at the laboratory without any preliminary crushing to constant weight at a temperature of not less than 104 nor more than 200° C.[1]

Calculate the loss in weight to percentage of moisture, which shall constitute the total moisture in the coke as received at the laboratory.

The allowable difference in duplicate determinations by the same analyst is 0.5 per cent.

Reduction of Sample.—Crush the dried sample mechanically with a jaw or roll crusher, or by hand on a chilled iron or hard-steel plate by impact of a hard bar or sledge, avoiding all rubbing action, as otherwise the ash content will be materially increased by the addition of iron from the sampling apparatus, even though hardened iron or steel is used. Continue the crushing until all the sample passes through a 4-mesh screen, mix and quarter this to not less than 5 lb.; again crush the 5-lb. sample to a fineness of 10-mesh; mix and quarter to 400 g. Transfer this 400-g. portion to the porcelain jar of an Abbé ball mill and pulverize to 60-mesh. When pulverization is complete, pour the contents of the jar on a $\frac{1}{2}$-in. screen and separate the sample from the pebbles by shaking the screen. Reduce the quantity of sample by quartering or riffling to about 50 g. Pass the entire 50-g. portion through a 60-mesh sieve, pulverizing any coarse particles in a diamond mortar, and mix with remainder of sample, preserving the sample for analysis in a rubber-stoppered glass bottle.

In case a ball mill is not available for fine grinding, quarter the 5-lb. 10-mesh sample to 200 g. and pulverize to 60-mesh, by impact in a hard-steel diamond mortar. The use of rubbing surfaces such as a disk pulverizer or a bucking board is never permissible for grinding coke.

NOTES.

The accuracy of the method of preparing laboratory samples should be checked frequently by resampling the rejected portions and preparing a duplicate sample. The ash in the two samples should not differ more than 0.4 per cent.

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[1] **Experiments made at the Bureau of Mines have shown that results checking within 0.5 per cent are obtained between these temperature limits.**

DETERMINATION OF MOISTURE.

Apparatus.

Moisture Oven.—An ordinary drying oven with openings for natural air circulation and capable of temperature regulation between limits of 104 and 110° C. may be used.

Capsules with Covers.—A convenient form, which allows the ash determination to be made on the same sample, is the Royal Meissen porcelain capsule No. 2, ⅞ in. deep and 1¾ in. in diameter.

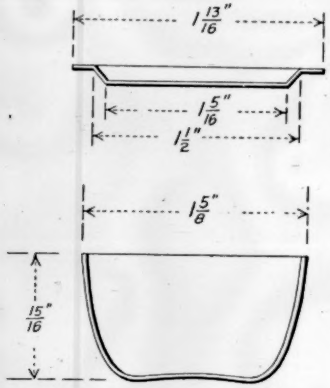

Fig. 2.—Porcelain Capsule with Flat Aluminum Cover.

This is to be used with a well-fitting flat aluminum cover, illustrated in Fig. 2.

Platinum crucibles or glass capsules with ground-glass caps may also be used. They should be as shallow as possible, consistent with convenient handling.

Method.

Heat the empty capsules under the conditions at which the coke is to be dried, stopper or cover, cool over concentrated sulfuric acid, sp. gr. 1.84, for 30 minutes, and weigh. Transfer to the capsule an amount slightly in excess of 1 g. and bring to exactly 1 g. in weight (±0.5 mg.) by quickly removing the excess weight of coke with a spatula.

Place the capsules, uncovered, in a pre-heated oven (at 104 to 110° C.). Close the oven at once and heat for 1 hour. Then open the oven, cover the capsules quickly and place them in a desiccator over concentrated sulfuric acid. When cool, weigh.

The percentage moisture in the 60-mesh sample shall be used to calculate the other results to a dry basis.

The permissible differences in duplicate determinations are as follows:

	PER CENT.
Same analyst	0.2
Different analysts	0.3

DETERMINATION OF ASH.

APPARATUS.

Gas or Electric Muffle Furnace or Meker Burner.—The muffle should have good air circulation and be capable of having its temperature regulated to not exceed 950° C.

Porcelain Capsules.—Royal Meissen Porcelain Capsules No. 2, $\frac{7}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, or similar shallow dishes or platinum crucibles.

METHOD.

Place the capsules containing the dried coke from the moisture determination in a muffle furnace or over a burner, and heat to redness at such a rate as to avoid mechanical loss. Finish the ignition to constant weight (±0.001 g.) at a temperature not exceeding 950° C. Cool in a desiccator and weigh.

The permissible differences in duplicate determinations are as follows:

	PER CENT.
Same analyst	0.2
Different analysts	0.3

NOTES.

Before replacing the capsules in the muffle for ignition to constant weight the ash should be stirred with a platinum or nichrome wire. Stirring once or twice before the first weighing hastens complete ignition.

Test the ash for unburned carbon, by moistening it with alcohol; any carbon remaining will show as black particles.

DETERMINATION OF VOLATILE MATTER.

APPARATUS.

Platinum Crucible with Tightly Fitting Cover.—The crucible should be of 10-cc. capacity, with capsule cover having thin flexible sides fitting down into crucible. Or the double-crucible method may be used, in which the sample is placed in a 10 or 20-cc. platinum crucible, which is then covered with another crucible of such a size that it will fit closely to the sides of the outer crucible, and its bottom will rest $\frac{1}{3}$ to $\frac{1}{2}$ in. above the bottom of the outer crucible.

Vertical Electric Tube Furnace; or a Gas or Electrically Heated Muffle Furnace.—The furnace may be of the form shown in Fig. 3. It is to be regulated to maintain a temperature of 950° C. (±20° C.) in the crucible, as shown by a thermocouple kept in the furnace. A Meker burner may be used, if satisfactory to both parties to the contract.

METHOD.

Weigh 1 g. of the coke in a weighed 10-cc. platinum crucible, close with capsule cover and place on platinum or nichrome-wire supports in the furnace chamber, which must be at a temperature of 950° C. (±20° C.). After the crucible has been heated 2 or 3 minutes tap the cover lightly to more perfectly seal the crucible and thus guard against the admission of air. After heating exactly 7 minutes, remove the crucible from the furnace and, without disturbing the cover, allow it to cool in a desiccator. Weigh as soon as cold. The loss of weight minus moisture equals the volatile matter.

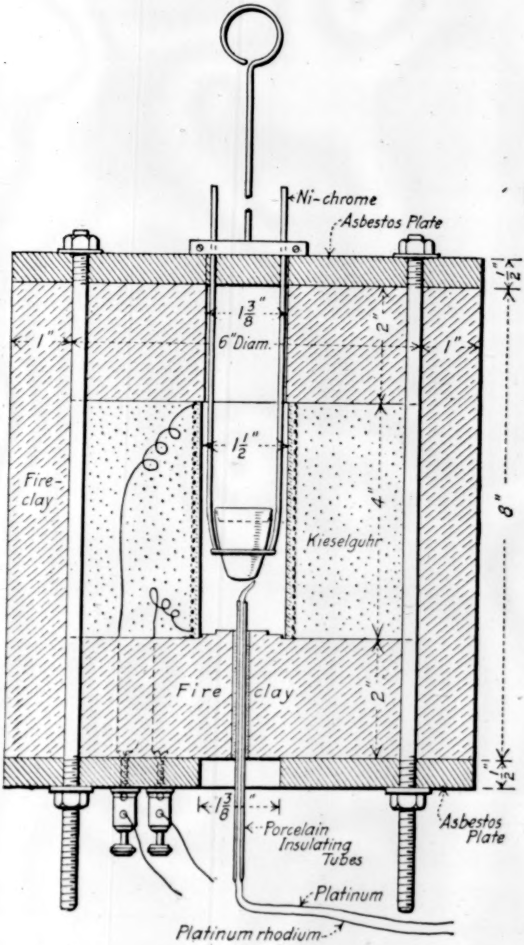
Ni-chrome
Asbestos Plate
1 3/8"
6" Diam.
1"
1"
1/2"
2"
1 1/2"
Fire-clay
Kieselguhr
4"
8"
Fire clay
2"
1/2"
1 3/8"
Porcelain Insulating Tubes
Asbestos Plate
Platinum
Platinum rhodium

FIG. 3.—Electric Tube Furnace for Determining Volatile Matter. For 110-volt Alternating Current, 60 ft. of Nichrome Wire, No. 17 B. & S. Gage will give the required temperature. The temperature must be controlled by an external resistance. (*Technical Paper No. 76*, Bureau of Mines, p. 21.)

The permissible differences in duplicate determinations are as follows:

	PER CENT.
Same analyst	0.2
Different analysts	0.4

ALTERNATE METHOD, USING MEKER BURNER.

Weigh 1 g. of the coke in a weighed 10 or 20-cc. platinum crucible, close with capsule cover or another crucible as described above under "apparatus," and place in the flame of a No. 4 Meker burner, having approximately an outside diameter at the top of 25 mm. and giving a flame not less than 15 cm. high. The temperature should be 950° C. (± 20° C.), as determined by placing a thermocouple through the perforated cover, which for this purpose may be of nickel or asbestos. The junction of the couple should be placed in contact with the center of the bottom of the crucible; or the temperature may be indicated by the fusion of pure potassium chromate in the covered crucible (fusion of K_2CrO_4, 940° C.). The crucible is placed in the flame about 1 cm. above the top of the burner and the heating is continued 7 minutes. Where the gas pressure is variable it is well to use a U-tube attachment to the burner.

DETERMINATION OF FIXED CARBON.

Compute fixed carbon as follows:

100 − (moisture + ash + volatile matter) = percentage of fixed carbon.

DETERMINATION OF SULFUR BY THE ESCHKA METHOD.

APPARATUS.

Gas or Electric Muffle Furnace, or Burners.—For igniting coke with the Eschka mixture and for igniting the barium sulfate.

Porcelain, Silica, or Platinum Crucibles or Capsules.—For igniting coke with the Eschka mixture.

No. 1 Royal Meissen porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.

No. 1 Royal Berlin porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coke owing to the deeper form, than with the shallow capsules described above.

No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the barium sulfate.

SOLUTIONS AND REAGENTS.

Barium Chloride.—Dissolve 100 g. of barium chloride in 1000 cc. of distilled water.

Saturated Bromine Water.—Add an excess of bromine to 1000 cc. of distilled water.

Eschka Mixture.—Thoroughly mix 2 parts (by weight) of light calcined magnesium oxide and 1 part of anhydrous sodium carbonate. Both materials should be free as possible from sulfur.

Methyl Orange.—Dissolve 0.02 g. in 100 cc. of hot distilled water and filter.

Hydrochloric Acid.—Mix 500 cc. of hydrochloric acid, sp. gr. 1.20, and 500 cc. of distilled water.

Normal Hydrochloric Acid.—Dilute 80 cc. of hydrochloric acid, sp. gr. 1.20, to 1 liter with distilled water.

Sodium Carbonate.—A saturated solution, approximately 60 g. of crystallized or 22 g. of anhydrous sodium carbonate in 100 cc. of distilled water.

Sodium-Hydroxide Solution.—Dissolve 100 g. in 1 liter of distilled water. This solution may be used in place of the sodium-carbonate solution.

METHOD.

Preparation of Sample and Mixture.—Thoroughly mix on glazed paper, 1 g. of 60-mesh coke and 3 g. of Eschka mixture.

Transfer to a No. 1 Royal Meissen porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 Royal Berlin crucible or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture.

Ignition.—On account of the amount of sulfur contained in artificial gas, the crucible shall be heated over an alcohol, gasoline or natural gas flame, as in procedure (*a*) below, or in a gas or electrically heated muffle, as in procedure (*b*) below. The use of artificial gas for heating the coke and Eschka mixture is permissible only when crucibles are heated in a muffle.

(*a*) Heat the crucible, placed in a slanting position on a triangle, over a low flame at first, then gradually increase the temperature and stir occasionally until all the black particles disappear, which is an indication of the completeness of the procedure.

(*b*) Place the crucible in a warm muffle and gradually raise the temperature to 870–925° C. (cherry-red heat) in about ½ hour. Maintain this maximum temperature until on stirring all black particles have disappeared.

Subsequent Treatment.—Remove and empty the contents into a 200-cc. beaker and digest with 100 cc. of hot water for ½ to ¾ hour, with occasional stirring. Filter and wash the insoluble matter by decantation. After several washings in this manner, transfer the insoluble matter to the filter and wash 5 times, keeping the mixture well agitated. Treat the filtrate, amounting to about 250 cc., with 10 to 20 cc. of saturated bromine water, make slightly acid with hydrochloric acid and boil to expel the liberated bromine. Make just neutral to methyl orange with sodium-hydroxide or sodium-carbonate solution, then add 1 cc. of normal HCl. Boil again and add slowly from a pipette with constant stirring 10 cc. of a 10-percent solution of barium chloride ($BaCl_2.2H_2O$). Continue boiling for 15 minutes and allow to stand for at least 2 hours, or preferably overnight, at a temperature just below boiling. Filter through an ashless filter paper and wash with hot distilled water until a silver-nitrate solution shows no precipitate with a drop of the filtrate. Place the wet filter containing the precipitate of barium-sulfate in a weighed platinum, porcelain, silica or alundum crucible, allowing a free access of air by folding the paper over the precipitate loosely to prevent spattering. Smoke the paper off gradually and at no time allow it to burn with flame. After the paper is practically consumed raise the temperature to approximately 925° C. and heat to constant weight.

The residue of magnesia, etc., after leaching, should be dissolved in hydrochloric acid and tested with great care for sulfur. When an appreciable amount is found this should be determined quantitatively. The amount of sulfur retained is by no means a negligible quantity.[1]

Blanks and Corrections.—In all cases a correction must be applied either (1) by running a blank exactly as described above, using the same amounts of all reagents that were employed in the regular determination, or, more surely, (2) by determining a known amount of sulfate added to a solution of the reagents after these have been put through the prescribed series of operations. If this latter procedure is adopted and carried out, say, once a week or whenever a new supply of a reagent must be used, and for a series of solutions covering the range of sulfur content likely to be met with in coke, it is only necessary to add or to subtract from the weight of barium sulfate obtained from a coke whatever deficiency or excess may have been found in the appropriate "check" in order to obtain a result that is more certain to be correct than if a "blank" correction as determined by the former procedure is applied. This is due to the fact that the solubility error for barium sulfate is, for the amounts of sulfur in question and the conditions of precipitation prescribed, probably the largest one to be considered. Barium sulfate is soluble[2] in acids and even in pure water, and the solubility limit is reached almost immediately on contact with the solvent. Hence, in the event of using reagents of very superior quality or of exercising more than ordinary precautions, there may be no apparent "blank," because the solubility limit of the solution for barium sulfate has not been reached, or at any rate not exceeded.

$$(\text{Weight of } BaSO_4 - \text{blank}) \times 13.73 = \text{percentage of sulfur.}$$

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[1] *Journal*, Am. Chem. Soc., Vol. 21, p. 1128 (1899).

[2] *Journal*, Am. Chem. Soc., Vol. 32, p. 588 (1910); Vol. 33, p. 829 (1911).

The permissible differences in duplicate determinations are as follows:

	PER CENT.
Same analyst	0.03
Different analysts	0.05

DETERMINATION OF PHOSPHORUS IN ASH.

Method No. 1. To Cover all Cases.—To the ash from 5 g. of coke in a platinum capsule is added 10 cc. of nitric acid and 3 to 5 cc. of hydrofluoric acid. The liquid is evaporated and the residue fused with 3 g. of sodium carbonate. If unburned carbon is present 0.2 g. of sodium nitrate is mixed with carbonate. The melt is leached with water and the solution filtered. The residue is ignited, fused with sodium carbonate alone, the melt leached and the solution filtered. The combined filtrates, held in a flask, are just acidified with nitric acid and concentrated to a volume of 100 cc. To the solution, brought to a temperature of 85° C., is added 50 cc. of molybdate solution and the flask is shaken for 10 minutes. If the precipitate does not form promptly and subside rapidly, add enough ammonium nitrate to cause it to do so. The precipitate is washed six times, or until free from acid, with a 2-per-cent solution of potassium nitrate, then returned to the flask and titrated with standard sodium-hydroxide solution. The alkali solution may well be made equal to 0.00025 g. of phosphorus per cubic centimeter, or 0.005 per cent, for a 5-g. sample of coke, and is 0.995 of one-fifth normal [1] Or the phosphorus in the precipitate is determined by reduction and titration of the molybdenum with permanganate.

Note on Method No. 1.—The advantage of the use of hydrofluoric acid in the initial attack of the ash lies in the resulting removal of silica. Fusion with alkali carbonate is necessary for the elimination of titanium, which if present and not removed will contaminate the phospho-molybdate and is said to sometimes retard its precipitation.

Method No. 2.—When titanium is so low as to offer no objection, the ash is decomposed as under method No. 1, but evaporation is carried only to a volume of about 5 cc. The solution is diluted with water to 30 cc., boiled and filtered. If the washings are turbid they are passed again through the filter. The residue is ignited in a platinum crucible, fused with a little sodium carbonate, the melt dissolved in nitric acid and its solution, if clear, added to the main one. If not clear it is filtered. The subsequent procedure is as under method No. 1. The fusion of the residue may be dispensed with in routine work on a given coke if it is certain that it is free from phosphorus.

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[1] Ulmann and Buch, *Chemical Engineer*, Vol. 10, p. 130 (1909).

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TENTATIVE METHODS
FOR
ANALYSIS OF CREOSOTE OIL.[1]

Serial Designation: D 38 - 17 T.

These methods are issued under the fixed designation D 38; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

(*F*) *Float Test of Residue.*

Apparatus. 1. (*a*) *Float or Saucer.*—The float or saucer shall be made of aluminum, and shall be of the form and dimensions shown in Fig. 1.

(*b*) *Conical Collar.*—The conical collar shall be made of brass, and shall be of the form and dimensions shown in Fig. 2.

Float Test Residue. 2. Place the brass collar with the small end on the brass plate, which has been previously amalgamated with mercury by first rubbing it with dilute solution of mercuric chloride or nitrate and then with mercury. Pour the residue to be tested into the collar direct from the retort, as described in Part (*D*) on "Distillation" of the Standard Methods for Sampling and Analysis of Creosote Oil (D 38-17) of the American Society for Testing Materials; or heat it in a tin box on water or steam bath, not by direct application of flame, and then pour into the collar in any convenient way, until slightly more than level with the top. The surplus may be removed after the material has cooled to room temperature, by means of spatula or steel knife which has been slightly heated. Then place the collar and plate in one of the tin cups containing ice water maintained at 5° C., and leave in this bath for at least 15 minutes.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1918, to Mr. Hermann von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

These methods, when adopted as standard will be added to the Standard Methods for Sampling and Analysis of Creosote Oil (D 38-17), "A.S.T.M. Standards adopted in 1917," p. 30.

Meanwhile, fill the other cup about three-fourths full of water and place on the tripod; heat the water to any desired temperature at which the test is to be made. This temperature should be accurately maintained, and should at no time throughout the entire test be allowed to vary more than 0°.5 C. from the temperature specified.

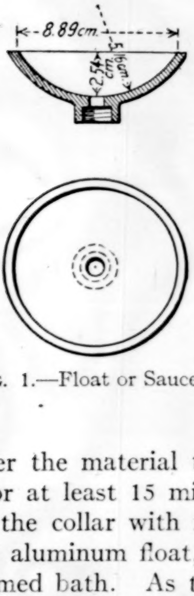

FIG. 1.—Float or Saucer.

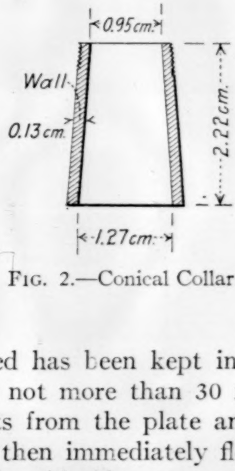

FIG. 2.—Conical Collar.

After the material to be tested has been kept in the ice water for at least 15 minutes and not more than 30 minutes, remove the collar with its contents from the plate and screw into the aluminum float, which is then immediately floated in the warmed bath. As the plug of residue becomes warm and fluid, it is forced upward and out of the collar, until the water gains entrance to the saucer and causes it to sink.

The time in seconds between placing the apparatus on the water and when the water breaks through the residue shall be determined by means of a stop watch, and shall be taken as a measure of the consistency of the material under examination.

(*G*) *Coke Residue.*

Apparatus. 3. *Bulb.*—The bulb shall be of hard glass, as shown in Fig. 3, and shall have the following approximate dimensions:

Diameter of bulb	15 mm.
Length of vertical neck	10 "
Length of horizontal neck	20 "
Diameter of orifice	1 "

Coke Residue Test. 4. Warm the bulb slightly to drive off all moisture, cool in a desiccator, and weigh. Again heat the bulb by placing it momentarily in an open Bunsen flame and place the tubular underneath the surface of the oil to be tested and allow the bulb to cool until sufficient oil is sucked in to fill the bulb about two-thirds full.

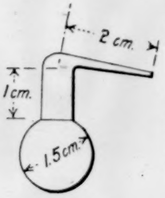

FIG. 3.—Coke Bulb.

Any globules of oil sticking to the inside of the tubular should be drawn into the bulb by shaking or expelled by slightly heating it, and the outer surface should be carefully wiped off and the bulb reweighed. This procedure will give about 1 g. of oil.

Cut a strip of thin asbestos paper about ¼ in. wide and about 1 in. long, place it around the neck of the bulb and catch the two free ends close up to the neck with a pair of crucible tongs. The oil should then be distilled off as in making ordinary oil distillation, starting with a very low flame and conducting the distillation as fast as can be maintained without spurting.

When oil ceases to come over, the heat should be increased until the highest temperature of the Bunsen flame is attained, the whole bulb being heated red hot until evolution of gas ceases, and any carbon sticking to the outside of the tubular is completely burned off. The bulb should then be cooled in a desiccator and weighed and the percentage of coke residue calculated to water-free oil.

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TENTATIVE GENERAL METHODS FOR TESTING COTTON FABRICS.[1]

Serial Designation: D 39 – 16 T.

These methods are issued under the fixed designation D 39; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1915; REVISED, 1916.

1. The following General Methods are intended to be applicable for testing cotton fabrics.[2] Where a material requires special treatment, specific methods will be described as they are developed for that material and such special tests shall have precedence over the general method.

I. DEFINITION OF MOISTURE.

Dry Condition.

2. The dry condition of cotton material shall be understood to be absolute dryness obtained by material placed in a ventilated drying oven maintained at a temperature of 105 to 110° C. (221 to 230° F.) and dried to constant weight as determined by two consecutive weighings not less than ten minutes apart, and showing a further loss of not more than 0.1 per cent of the previous weighing.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1918, to Mr. G. B. Haven, Chairman of Committee D-13 on Textile Material, Massachusetts Institute of Technology, Cambridge, Mass.

[2] In preparing these methods, Committee D-13 has had in mind especially automobile tire fabrics, hose and belting duck, and ordinary plain-weave cotton fabrics.

Standard Condition. 3. The standard condition[1] of cotton material shall be understood to be the condition in which it contains 8.5 per cent of its dry weight of moisture.

II. CHARACTERISTICS OF ROLL OR PIECE.

(*A*) *Length.*

Length. 4. The length of a roll or piece shall be determined by running the cloth over a measuring drum of known circumference, from which the yardage is registered by a dial or counter driven by a chain or other positive or non-slip mechanism. Just enough uniform tension[2] is to be used on the cloth to keep it running flat and true.

(*B*) *Width.*

Width. 5. (*a*) The width of a roll or piece shall be determined at five different places uniformly distributed along the full length of the roll or piece, and may be determined at the same time as the total length.

(*b*) The average of the five measurements shall be the width.

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[1] The amount of moisture which cotton contains when it is in moisture equilibrium with the space surrounding it, depends on both the relative humidity and the temperature. There is therefore a series of relative humidity-temperature values at which cotton will be in the "Standard Condition." The following table of values has been selected from Hartshorne's Unit Chart C. 2, and is published for the assistance of those who may be unable to control both the temperature and humidity to a single pair of values.

RELATIVE HUMIDITY-TEMPERATURE VALUES AT WHICH COTTON CONTAINS 8.5 PER CENT OF ITS DRY WEIGHT OF MOISTURE.

Temperature, deg. Fahr.	Relative Humidity, per cent.	Temperature, deg. Fahr.	Relative Humidity, per cent.
40	60.00	75	63.75
45	60.50	80	64.25
50	61.00	85	64.75
55	61.50	90	65.25
60	62.00	95	65.75
65	62.75	100	66.25
70	63.25		

[2] It has been suggested that a uniform tension of 2.5 times the weight of five running yards of the fabric will be sufficient to keep the fabric flat and preserve a proper relation for comparison of different fabrics. Invitation is extended to report to the committee the results of such tests upon different fabrics.

(*C*) *Weight.*

Net Weight.

6. All covering and binding material shall be removed and the net weight of the roll or piece quickly determined. A sample for the moisture test (described in Section 7) shall be taken immediately. The length and the width of the roll or piece (described in Sections 4 and 5) shall be determined quickly and accurately. As soon as the inner end is reached, a second moisture sample shall be taken.

Moisture. Content.

7. For the determination of the moisture content two test specimens of approximately equal area, the combined weight of which shall be at least 3.5 oz.[1] (100 g.), shall be taken as described in Section 6, one from each end of the roll or piece, placed in a dry, air-tight container, the weight of which has been previously determined, carefully weighed therein, then removed (a check weighing being made on the container), the net weight calculated and the sample dried to constant weight in the manner as described in Section 2 for dry condition. The difference between the original net weight of the sample and its dry weight is the loss of moisture. The percentage that this loss is of the original weight shall be considered the percentage moisture content of the roll.

Dry Weight.

8. The net weight of the roll or piece, less that weight multiplied by the percentage moisture content found as in Section 7, shall be considered the dry weight of the roll or piece.

The dry weight may also be computed from the moisture test by the following proportion:

$$\frac{\text{Net weight of sample}}{\text{Dry weight of sample}} = \frac{\text{Net weight of roll or piece}}{\text{Dry weight of roll or piece}}$$

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[1] For a fabric weighing 17½ oz. per sq. yd., at least 260 sq. in., 130 sq. in. from each end, would be required. It is not necessary that each of these test specimens be a continuous piece, but a strip 2.5 to 3 in. wide cut the entire width of a 60-in. fabric forms a convenient and representative sample because it contains portions of both the ends and the middle of the roll. If for other purposes of comparison it is desired to have the specimens of definite shape or aliquot parts of a square yard such as 9 or 16 or 24 sq. in., they may be conveniently cut with a sharp-edge circular die pressed upon a smooth but not too-hard surface such as block tin or sheet lead. Equal total areas could in this manner be readily taken from each end of the roll. Care should be exercised to handle the moisture specimens as little as possible, preferably with the hands covered by some type of dry, non-absorbent gloves and to place them in the air-tight weighing container immediately.

III. CHARACTERISTICS OF FABRIC.

(*A*) *Number of Threads per Inch.*

Number of Threads per Inch.

9. (*a*) The number of threads per inch or count of the fabric shall be determined by counting a space of at least 1 in. in at least five different places in the roll.

(*b*) The average of the five determinations shall be the count.

(*B*) *Weight.*

Weight.

10. The weight of the fabric per square yard shall be based upon the weight and length of a complete roll or piece and may be expressed either as (*a*) the dry weight, or (*b*) the standard weight, corresponding to "dry condition" and "standard condition," respectively.

For condition (*a*):

$$\text{Dry weight per square yard} = \frac{\text{Dry weight of roll}}{\text{Area of roll in square yards}}$$

For condition (*b*):

$$\left.\begin{array}{c}\text{Standard weight per}\\ \text{square yard}\end{array}\right\} = \frac{\text{Dry weight of roll} + (8.5 \text{ per cent of dry weight})}{\text{Area of roll in square yards.}}$$

(*C*) *Thickness.*

Thickness.

11. (*a*) The thickness shall be measured by an automatic micrometer which presses upon at least 0.5 sq. in. of the fabric with a uniform constant pressure, and which is so mounted as to make measurements 6 in. from the selvage.

(*b*) At least ten measurements at different portions of the roll or piece shall be made, and the average shall be the thickness of the fabric.

(*D*) *Strength.*

Sampling.

12. For the determination of strength a 12-in. swatch, the width of the cloth, shall be taken from either end of the roll or piece, and the test specimens cut from it and tested as specified later. If by the first tests the fabric fails to meet the specifications a second swatch shall be taken as follows:

If the roll or piece is a complete warp, the second swatch shall be cut from the center of the roll or piece. If the roll or piece is a part warp the second swatch shall be taken not less than 1½ yd. from the other end.

Speed.

13 The pulling clamp of the testing machine shall be power driven and shall travel at a uniform rate of 20 in. per minute.

Reporting Results.

14. The average results of tests should be reported separately for warp and filling.

Methods.

15. The strength may be determined either by (*a*) the "Strip Method" or (*b*) the "Grab Method."

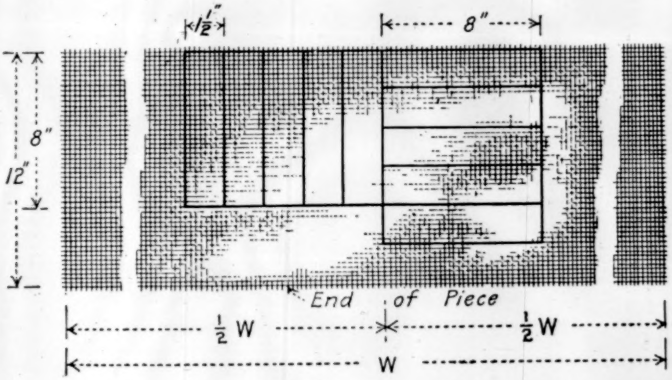

FIG. 1.—Location of Test Specimens, Strip Method.

Strip Method.

Preparation of Specimens: Strip Method.

16. (*a*) The test specimens shall be taken as follows: Starting at a line in the center, warpwise, lay off adjacent to this line five specimens on one side, parallel to the line (warp) and five specimens on the other side perpendicular to the line (filling). The test specimens shall be cut 8 in. long by 1½ in. wide, and shall be ravelled to the specified number of threads per inch by removing approximately an equal number of threads from each side of the required width. (See Fig. 1).

(*b*) Draw two parallel lines 3 in. apart on each test specimen as it lies flat without tension upon a smooth surface.[1]

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[1] These lines should be sharp and distinct. They may be quickly, conveniently and accurately made with a die, inked by means of an ordinary stamp pad. The die may consist of two metal strips set crosswise of the grain into a well-seasoned block of hard wood, the inner faces milled accurately parallel and 3 in. apart and the outer faces ground away so as to form a fine, but non-cutting edge. A die entirely of metal would of course be superior.

Clamps. 17. All jaws or clamps shall be at least 2 in. wide, and shall be of such design as to hold all threads without cutting or slipping.

Length of Specimen. 18. The length of test specimen between the jaws or clamps of the testing machine shall be 3 in.

Elongation. 19. The elongation or stretch at breaking shall be determined by measuring at the instant of breakage, by suitable means, the distance between the lines drawn 3 in. apart as specified in Section 16 (*b*). The increase in length of the 3-in. portion shall be the elongation and may be expressed either in units of length or as the percentage of 3 in.

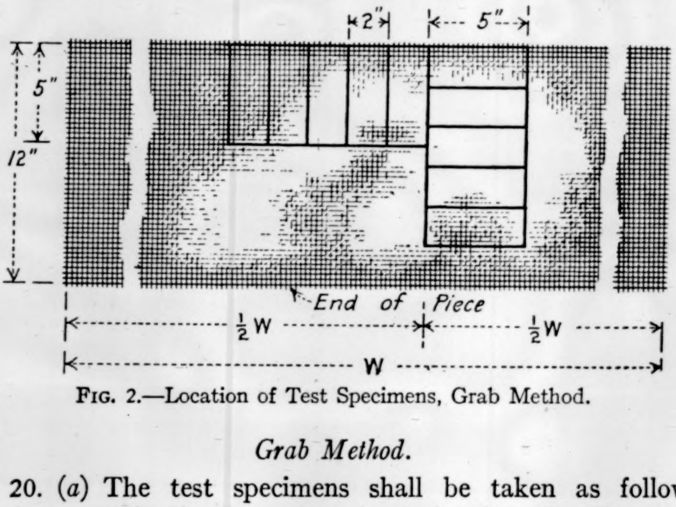

FIG. 2.—Location of Test Specimens, Grab Method.

Grab Method.

Preparation of Specimens: Grab Method. 20. (*a*) The test specimens shall be taken as follows: Starting at a line in the center, warpwise, lay off adjacent to this line five specimens on one side, parallel to the line (warp) and five specimens on the other side perpendicular to the line (filling). The test specimens shall be cut 5 in. long by 2 in. wide. (See Fig. 2.)

(*b*) On each test specimen as it lies flat without tension on a smooth surface, draw pencil lines along the thread vertically and ½ in. from each edge so that 1 in. of fabric will be between them. Then draw pencil lines along the thread horizontally and 1 in. apart in the center of the specimen.

Clamps. 21. (*a*) On a vertical machine, use jaws at least 2 in. wide for the back, at both top and bottom, and 1-in. jaws for the front at both top and bottom.

(*b*) On a horizontal machine, use jaws at least 2 in. wide for the under ones and 1-in. jaws for the upper ones.

Clamping of Specimen.

22. The test specimen shall be securely clamped in the two jaws of the machine, care being taken to see that the threads being tested are parallel to the direction of the pull and the cross threads are perpendicular to that direction.

Length of Specimen.

23. The length of test specimen between the jaws or clamps of the testing machine shall be 1 in.

Elongation.

24. The elongation or stretch at breaking shall be determined by measuring at the instant of breakage, by suitable means, the distance between the lines drawn 1 in. apart as specified in Section 20 (*b*). The increase in length of the 1-in. portion shall be the elongation and may be expressed either in units of length or as the percentage of 1 in.

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TENTATIVE DEFINITIONS OF TERMS RELATING TO MATERIALS FOR ROADS AND PAVEMENTS.[1]

Serial Designation: D 8 – 17 T.

These definitions are issued under the fixed designation D 8; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; SUPPLEMENTED, 1917.

Clinker.—Generally a fused or partly fused by-product of the combustion of coal, but also including lava and Portland-cement clinker, and partly vitrified slag and brick.

Mesh.—The square opening of a sieve.

Slag.—Fused or partly fused compounds of silica in combination with lime or other bases, resulting in secondary products from the reduction of metallic ores.

Petroleum.—Liquid bitumen occurring as such in nature.

Topped Petroleum.—Petroleum deprived of its more volatile constituents.

Rock Asphalt.—Sandstone or limestone naturally impregnated with asphalt.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed, preferably before January 1, 1918, to Mr. L. W. Page, Chairman of Committee D-4 on Road Materials, U. S. Office of Public Roads and Rural Engineering, Washington, D. C.

These definitions, when adopted as standard, will be added to the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8–15), 1916 Book of A.S.T.M. Standards, p. 594.

Bituminous Emulsion.—A liquid mixture in which minute globules of bitumen are held in suspension in water or a watery solution.

Viscosity.—The measure of the resistance to flow of a bituminous material, usually stated as the time of flow of a given amount of the material through a given orifice.

Penetration.—The consistency of a bituminous material expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time and temperature. Where the conditions of test are not specifically mentioned, the load, time and temperature are understood to be 100 g., 5 seconds, and 25° C. (77° F.), respectively, and the units of penetration to indicate hundredths of a centimeter.

Aggregate.—The inert material, such as sand, gravel, shell, slag or broken stone or combinations thereof, with which the cementing material is mixed to form a mortar or concrete.

Screen.—In laboratory work an apparatus, in which the apertures are circular, for separating sizes of material.

Sieve.—In laboratory work an apparatus, in which the apertures are square, for separating sizes of material.

Bank Gravel.—Gravel found in natural deposits, usually more or less intermixed with fine material, such as sand or clay, or combinations thereof; gravelly clay, gravelly sand, clayey gravel and sandy gravel, indicate the varying proportions of the materials in the mixture.

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TENTATIVE DEFINITIONS AND RULES GOVERNING THE PREPARATION OF MICROGRAPHS OF METALS AND ALLOYS.[1]

Serial Designation: E 2 - 17 T.

These definitions and rules are issued under the fixed designation E 2; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. STANDARD MAGNIFICATIONS.

General Use.

1. The standard magnifications for general use in making micrographs, expressed in diameters, shall be as follows:

10, 25, 50, 75, 100, 150, 250, 500, 750, 1000.

Ferrous Metals.

2. (*a*) The standard magnifications for making micrographs of steel and ferrous materials shall be:

50, 100, 250, 500.

(*b*) For general use in Society reports, and for showing grain size, a magnification of 100 diameters shall be used.

Non-Ferrous Metals.

3. (*a*) The standard magnifications for making micrographs of non-ferrous metals shall be:

25, 75, 150, 250.

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[1] Criticisms of these Tentative Definitions and Rules are solicited and should be directed, preferably before January 1, 1918, to Mr. W. H. Bassett, Chairman of Committee E-4 on Magnification Scales for Micrographs, American Brass Co., Waterbury, Conn.

(*b*) For general use in Society reports, and for showing grain size of copper and copper alloys, a magnification of 75 diameters shall be used.

Reproduction of Micrographs.

4. (*a*) Reproductions of micrographs in publications shall be made of exact standard magnifications.

(*b*) If micrographs submitted for publication are not of standard magnification, they shall be enlarged or reduced to the nearest standard size. The actual magnification appearing in print shall be stated under the micrograph. See Paragraph (*d*).

(*c*) To facilitate the reproduction, authors should be advised that their micrographs should be of proper size to fit the printed page, and in order to conserve space that micrographs be printed in the form of squares.

(*d*) With each micrograph shall be printed an explanatory title, together with actual magnification, etching medium, treatment, etc., indicating what the author intends to show, so that it will not be necessary to search the text for general information.

II. LENSES.

Lenses.

5. For obtaining the magnifications recommended, the following types of lenses are suggested as suitable for general commercial work:

(*a*) For magnifications from 20 to 50: A lens of the microplanar or microtessar type (*e. g.*, 20-mm. focal length); no ocular is required.

(*b*) For magnifications from 30 to 75: A 32-mm. objective with Huyghens ocular (approximately ×5).

(*c*) For magnifications from 75 to 150: A 16-mm. objective with Huyghens ocular (approximately ×5).

(*d*) For magnifications from 250 to 500: A 4-mm. objective (preferably apochromatic) with projection ocular.

Directions.

6. (*a*) All objectives should be corrected for uncovered objects.

(*b*) In using one of the lens combinations given above, the length of the camera bellows may be adjusted to give the exact magnification desired.

It should be borne in mind, however, that increasing the magnification by increasing the length of the camera bellows adds nothing to the detail of the micrograph. This depends entirely upon the resolving power of the objective used.

III. GRAIN SIZE.

Definition of Grain.

7. (*a*) *Alloys Consisting of but One Type of Crystals* (*e. g.*, copper, alpha brass, etc.): In counting individual grains the original crystal, including the twinned layers, shall be called one grain.

(*b*) *Alloys Consisting of Two Metallographic Components* (*e. g.*, steels, Muntz metal, etc.): The original grain which has given rise to the aggregation of the two components shall be taken as the unit when determinable and the individual component in other cases.[1] When grain size is included in actual specifications, the term should always be defined in such specifications.

Method of Measurement of Grain Size.

8. For measuring grain size, two methods are recommended depending upon the condition of the material:

(*a*) *For Material in which the Grains are Equi-axed* (*e. g.*, most metals in the cast and in the annealed state): The planimetric method as modified by Jeffries[2] is recommended for use as being very accurate and rapid. It is recommended that the circular area used should always include at least 50 grains.

(*b*) *When the Grains are not Equi-axed* (*e. g.*, in strained materials): Heyn's intercept method should be used, the average grain size being determined by counting the number of grains at a given magnification along a line of known length on two axes at right angles to each other, one axis being parallel to the direction of rolling. In some cases a third count along a line perpendicular to the other two may be desirable. This will necessitate the preparation of another polished surface.

Numerical Expression of Grain Size.

9. The grain size as determined by the plani metric method, Section 8 (*a*), should be expressed as the number of grains per unit area (square inch or square centimeter). This may also, but less preferably so, be expressed as the average grain area; or the average linear dimension of the grain may be given. The grain size as determined by the intercept method, Section 8 (*b*), should be expressed by giving the average number of grains per linear unit in the two directions; or the average

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[1] See U. S. Navy Specifications, 49-S-2-c, p. 7.

[2] *Transactions*, Am. Inst. Mining Engrs., Vol. LIV, pp. 594–607 (1916).

number per unit area together with the ratio of length to breadth of grain (L/B) may be given.

Use of Grain Size in Specifications.

10. If grain size is to be included in specifications, it should be expressed as the maximum or minimum allowable as determined above. It is recommended that only in extreme cases should grain size be made the sole basis of rejection of material.

LIST OF TENTATIVE STANDARDS

PUBLISHED BY THE

AMERICAN SOCIETY FOR TESTING MATERIALS.[1]

The term Tentative Standards is applied to proposed Standards which are printed in the Proceedings for one or two years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards the adoption of such Tentative Standards by formal action of the Society.

These Tentative Standards are all copyrighted in the name of the American Society for Testing Materials. Permission to reprint any of these Tentative Standards can be obtained only from the Executive Committee on application to the Secretary-Treasurer.

The designations A 65, A 66, etc., of the Tentative Standards are fixed; they follow in numeric sequence the designations of the Standards, and are retained when a Tentative Standard is adopted as Standard. The final numbers 16, 17, etc., indicate the year of original issue, or in the case of revision, the year of last revision. The letter "T" is appended to the designation of all Tentative Standards. The serial designations of Tentative Standards which have for any reason not been adopted as standard, and have been discontinued, are permanently dropped. In ordering Tentative Standards, the complete serial designations A 65-16 T, etc., should be stated.

A. FERROUS METALS.

STEEL.

TENTATIVE SPECIFICATIONS.

A 65-16 T. For Steel Track Spikes.

Proposed in 1916 (Volume XVI, Part I, pp. 410-411).

A 66-16 T. For Steel Screw Spikes.

Proposed in 1916 (Volume XVI, Part I, pp. 412-413).

A 67-17 T. For Steel Tie Plates.

Proposed in 1916 (Volume XVI, Part I, pp. 414-417).
Revised in 1917 (Volume XVII, Part I, pp. 87, 120).

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[1] **For complete list of Tentative Standards by titles with serial designations in continuous numeric sequence, see appendix to this List, p. 228.**

A 68–16 T. **For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements.**

Proposed in 1916 (Volume XVI, Part I, pp. 418–420).

A 69–16 T. **For Elliptical Springs for Automobiles.**

Proposed in 1916 (Volume XVI, Part I, pp. 421–428).

A 70–17 T. **For Boiler and Firebox Steel for Stationary Service.**

Proposed in 1916 (Volume XVI, Part I, pp. 429–433).
Revised in 1917 (Volume XVII, Part I, pp. 87, 110, 120).

A 71–17 T. For Carbon Tool Steel.

Proposed in 1917 (Volume XVII, Part I, pp. 87, 120).

WROUGHT IRON.

TENTATIVE SPECIFICATIONS.

A 39–17 T. For Staybolt Iron.

Proposed in 1917 (Volume XVII, Part I, pp. 130–132).

To replace, when adopted, the Standard Specifications for Staybolt Iron (Serial Designation: A 39–14).

A 72–17 T. For Wrought-Iron Pipe.

Proposed in 1917 (Volume XVII, Part I, pp. 130–132).

To replace as a separate specification, when adopted, the requirements for wrought-iron pipe in the Standard Specifications for Welded Steel and Wrought-Iron Pipe (Serial Designation: A 53–15).

A 73–17 T. For Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars.

Proposed in 1917 (Volume XVII, Part I, pp. 130–132).

CAST IRON.

TENTATIVE SPECIFICATIONS.

A 74–17 T. For Cast-Iron Soil Pipe and Fittings.

Proposed in 1917 (Volume XVII, Part I, pp. 133–134).

A 75–17 T. For Railroad Malleable-Iron Castings.

Proposed in 1917 (Volume XVII, Part I, pp. 133–134).

B. NON-FERROUS METALS.

TENTATIVE SPECIFICATIONS.

B 10–15 T. For the Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent.

Proposed in 1915 (Volume XV, Part I, pp. 137–138; 1915 Year-Book, pp. 550–552).

B 11–16 T. For Copper Plates for Locomotive Fireboxes.

Proposed in 1916 (Volume XVI, Part I, pp. 437–440).

B 12–16 T. For Copper Bars for Locomotive Staybolts.

Proposed in 1916 (Volume XVI, Part I, pp. 441–443).

B 13–16 T. For Seamless Copper Boiler Tubes.

Proposed in 1916 (Volume XVI, Part I, pp. 444–447).

B 14–16 T. For Seamless Brass Boiler Tubes.

Proposed in 1916 (Volume XVI, Part I, pp. 448–451).

B 15–17 T. For Brass Forging Rod.

Proposed in 1917 (Volume XVII, Part I, pp. 178–179, 195).

B 16–17 T. For Free-Cutting Brass Rod for Use in Screw Machines.

Proposed in 1917 (Volume XVII, Part I, pp. 178–179, 195).

B 17–17 T. For Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings.

Proposed in 1917 (Volume XVII, Part I, pp. 178-179, 195).

B 6–17 T. For Spelter.

Proposed in 1916 (Volume XVI, Part I, pp. 583–589).
Revised in 1917 (Volume XVII, Part I, pp. 178-179, 195).

To replace, when adopted, the Standard Specifications for Spelter (Serial Designation: B 6–14).

TENTATIVE METHODS.

B 18–17 T. For Analysis of Alloys of Lead, Tin, Antimony and Copper.

Proposed in 1917 (Volume XVII, Part I, p. 195).

C. CEMENT, LIME, GYPSUM, AND CLAY PRODUCTS.

TENTATIVE SPECIFICATIONS.

C 9–16 T. Specifications and Tests for Compressive Strength of Portland-Cement Mortars.

Proposed in 1916 (Volume XVI, Part I, pp. 590–593).

To be added, when adopted, to the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9–17).

C 13–17 T. For Clay Sewer Pipe.

Proposed in 1917 (Volume XVII, Part I, pp. 293–294).

C 14–17 T. For Cement-Concrete Sewer Pipe.

Proposed in 1917 (Volume XVII, Part I, pp. 293–294).

C 15–17 T. For Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling.

Proposed in 1917 (Volume XVII, Part I, pp. 293–294).

C 6–17 T. For Masons' Hydrated Lime.

Proposed in 1917 (Volume XVII, Part I, p. 312).

To replace, when adopted, the Standard Specifications for Hydrated Lime (Serial Designation: C 6–15).

TENTATIVE TESTS.

C 16–17 T. For Refractory Materials under Load at High Temperatures.

Proposed in 1917 (Volume XVII, Part I, p. 313).

C 17–17 T. For Slagging Action of Refractory Materials.

Proposed in 1917 (Volume XVII, Part I, p. 313).

TENTATIVE METHODS.

C 18–17 T. For Ultimate Chemical Analysis of Refractory Materials.

Proposed in 1917 (Volume XVII, Part I, p. 313).

C 19–17 T. For Control of Fire Tests and Classification of Materials and Construction as Determined by Test.

Proposed in 1917 (Volume XVII, Part I, pp. 295–299).

TENTATIVE DEFINITIONS.

C 11–16 T. **Of Terms Relating to the Gypsum Industry.**

Proposed in 1916 (Volume XVI, Part I, pp. 452–471).

TENTATIVE RECOMMENDED PRACTICE.

C 12–17 T. **For Laying Sewer Pipe.**

Proposed in 1915 (Volume XV, Part I, pp. 163–164; 1915 Year-Book, pp. 553–558).

Continued as tentative in amended form in 1916 (Volume XVI, Part I, pp. 472–478).

Continued as tentative in amended form in 1917 (Volume XVII, Part I, pp. 293–294).

D. MISCELLANEOUS MATERIALS.

TENTATIVE SPECIFICATIONS.

D 23–16 T. **For Selected Structural Douglas Fir Bridge and Trestle Timbers.**

Proposed in 1916 (Volume XVI, Part I, pp. 479–482).

D 24–15 T. **For Southern Yellow-Pine Timber to be Creosoted.**

Proposed in 1915 (Volume XV, Part I, pp. 365–366; 1915 Year-Book, pp. 563–564).

D 25–15 T. **For Southern Yellow-Pine Piles and Poles to be Creosoted.**

Proposed in 1915 (Volume XV, Part I. pp. 365–366; 1915 Year-Book, pp. 565–566).

D 40–17 T. **For Asphalt for Use in Damp-proofing and Waterproofing.**

Proposed in 1917 (Volume XVII, Part I, pp. 487–488).

D 41–17 T. **For Primer for Use with Asphalt for Use in Damp-proofing and Waterproofing.**

Proposed in 1917 (Volume XVII, Part I, pp. 487–488).

D 42–17 T. **For Coal-Tar Pitch for Use in Damp-proofing and Waterproofing.**

Proposed in 1917 (Volume XVII, Part I, pp. 487–488).

D 43–17 T. **For Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing.**

Proposed in 1917 (Volume XVII, Part I, pp. 487–488).

D 44–17 T. For Canned Foods Boxes, Nailed and Lock-Corner Construction.

Proposed in 1917 (Volume XVII, Part I, p. 493).

D 45–17 T. For Canned Foods Boxes, Wirebound Construction.

Proposed in 1917 (Volume XVII, Part I, p. 493).

D 26–16 T. For 2½, 3, and 3½-in. Double-Jacketed Cotton Rubber-Lined Fire Hose for Public Fire Department Use.

Proposed in 1916 (Volume XVI, Part I, pp. 487–491).

D 27–16 T. For Insulated Wire and Cable: 30 per cent Hevea Rubber.

Proposed in 1916 (Volume XVI, Part I, pp. 492–517).

D 46–17 T. For Air-Line Hose for Pneumatic Tools.

Proposed in 1917 (Volume XVII, Part I, pp. 494–496).

TENTATIVE TESTS.

D 47–17 T. For Lubricants.

Proposed in 1917 (Volume XVII, Part I, pp. 462–470).

D 3–17 T. For Toughness of Rock.

Proposed in 1917 (Volume XVII, Part I, pp. 470–473).

To replace, when adopted, the Standard Test for Toughness of Macadam Rock (Serial Designation: D 3–08).

D 30–17 T. For Determination of Apparent Specific Gravity of Coarse Aggregates.

Proposed in 1916 (Volume XVI, Part I, pp. 529–530).
Revised in 1917 (Volume XVII, Part I, pp. 470–473).

D 48–17 T. For Molded Insulating Materials.

Proposed in 1917 (Volume XVII, Part I, pp. 489–490).

D 31–16 T. For Automobile Tire Fabrics.

Proposed in 1916 (Volume XVI, Part I, pp. 531–532).

D 32–16 T. For Cotton Fabrics for Use in Hose, Belting, and Similar Articles.

Proposed in 1916 (Volume XVI, Part I, p. 533).

D 33–16 T. For Cotton Fabrics for Use in Bags and Bagging Material.

Proposed in 1916 (Volume XVI, Part I, pp. 534–535).

TENTATIVE METHODS.

D 49–17 T. For Routine Analysis of Dry Red Lead.

Presented as information in 1914 (Volume XIV, Part I, pp. 281–283).

Proposed as tentative in 1917 (Volume XVII, Part I, pp. 363, 385, 460).

D 50–17 T. For Routine Analysis of Yellow, Orange, Red and Brown Pigments containing Iron and Manganese.

Proposed in 1917 (Volume XVII, Part I, pp. 363, 385, 460).

D 35–16 T. Form of Specifications for Certain Commercial Grades of Broken Stone.

Proposed in 1916 (Volume XVI, Part I, p. 548).

D 36–16 T. For Determination of Softening Point of Bituminous Materials Other than Tar Products.

Proposed in 1916 (Volume XVI, Part I, pp. 549–550).

D 37–16 T. For Laboratory Sampling and Analysis of Coke.

Proposed in 1916 (Volume XVI, Part I, pp. 551–563).

D 38–17 T. For Analysis of Creosote Oil.

Proposed in 1917 (Volume XVII, Part I, pp. 483–486).

To be added, when adopted, to the Standard Methods for Sampling and Analysis of Creosote Oil (Serial Designation: D 38–17).

D 39–16 T. For Testing Cotton Fabrics.

Proposed in 1915 (Volume XV, Part I, pp. 440–442; 1915 Year-Book, pp. 574–578).

Continued as tentative in amended form in 1916 (Volume XVI, Part I, pp. 572–578).

TENTATIVE DEFINITIONS.

D 8–17 T. Of Terms Relating to Materials for Roads and Pavements.

Proposed in 1916 (Volume XVI, Part I, pp. 303–305).

Additional Definitions proposed in 1917 (Volume XVII, Part I, pp. 471–473).

To be added, when adopted, to the Standard Definitions of Terms Relating to Materials for Roads and Pavements (Serial Designation: D 8–15).

E. MISCELLANEOUS SUBJECTS.

TENTATIVE DEFINITIONS.

E 2–17 T. Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys.

Proposed in 1917 (Volume XVII, Part I, p. 508).

TENTATIVE REVISIONS OF STANDARDS.

Revisions in the Standards indicated below (with the exception of Specification A 34–14) were proposed at the annual meeting in 1917, by the respective committees, to be published for one or two years before final action is taken on their adoption as standard. These proposed revisions appear in these Proceedings (Vol. XVII, Part I), under the respective committee reports, at the pages designated.

STANDARD SPECIFICATIONS.

Committee A-1 on Steel (pages 97–110).

A 17–13. For Blooms, Billets and Slabs for Carbon-Steel Forgings.

A 18–16. For Carbon-Steel and Alloy-Steel Forgings.

A 19–16. For Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars.

A 63–16. For Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars.

A 21–14. For Carbon-Steel Car and Tender Axles.

A 28–16. For Lap-Welded and Seamless Steel Boiler Tubes, Boiler Flues, Superheater Pipes, Safe Ends, and Arch Tubes for Locomotives.

A 52–15. For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service.

A 53–15. For Welded Steel and Wrought-Iron Pipe.

A 29–16. For Automobile Carbon and Alloy Steels.

A 30–16. For Boiler and Firebox Steel for Locomotives.

Committee A-2 on Wrought Iron (pages 131–132).

A 41–13. For Refined Wrought-Iron Bars.

Committee A-3 on Cast Iron (page 133).

A 48–05. For Gray-Iron Castings.

STANDARD TESTS.

Committee A-6 on Magnetic Testing.

A 34–14. For Magnetic Properties of Iron and Steel.
Proposed in 1916 (Volume XVI, Part I, pp. 171–176).

Committee C-5 on Fireproofing (pages 295–299).

C 2–08. For Fireproof Floor Construction.
C 3–09. For Fireproof Partition Construction.

STANDARD METHODS.

Committee D-4 on Road Materials (pages 474–475).

D 20–16. For Distillation of Bituminous Materials Suitable for Road Treatment.

Committee E-1 on Methods of Testing (pages 499–501).

E 1–16. For Testing.

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VOLUME XVII, PART I.

SUBJECT INDEX.

A

Absorption Tests.
  — of Tile. Appendix II, Report of Committee C-10, 353.
Address.
  Addresses by Past Presidents:
    A. W. Gibbs, 50; Arthur N. Talbot, 51; Robert W. Hunt, 52; Henry M. Howe, 54; Mansfield Merriman, 55.
  Annual — by the President, A. A. Stevenson, 34.
Aggregates (see also **Rock, Stone**).
  Concrete and Concrete —. Report of Committee C-9, 319.
  Tentative Test for Determination of Apparent Specific Gravity of Coarse —, 776.
Air-Line Hose.
  See **Hose.**
Alloys.
  Non-Ferrous Metals and —. Report of Committee B-2, 178.
  Sand-Cast Metals and —. Appendix II, Report of Sub-Committee III of Committee B-2, 182.
  Tentative Methods for Analysis of — of Lead, Tin, Antimony and Copper, 622.
  Tentative Specifications for the Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent, 585.
  Tentative Specifications for Non-Ferrous — for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings, 610.
American Society for Testing Materials.
  Officers and Members of the Executive Committee of —, 851.
Analysis.
  Tentative Methods for — of Alloys of Lead, Tin, Antimony and Copper, 622.
  Tentative Methods for — of Creosote Oil, 826.
  Tentative Methods for Laboratory Sampling and — of Coke, 813.
  Tentative Methods for Routine — of Dry Red Lead, 796.
  Tentative Methods for Routine — of Yellow, Orange, Red and Brown Pigments containing Iron and Manganese, 802.
  Tentative Methods for Ultimate Chemical — of Refractory Materials, 671.
Annual Meeting.
  Summary of the Proceedings of the Twentieth —, 9.

Antimony.
  Tentative Methods for Analysis of Alloys of Lead, Tin, — and Copper, 622.
Asphalt.
  Tentative Specifications for — for Use in Damp-proofing and Waterproofing, 712.
  Tentative Specifications for Primer for Use with — for Use in Damp-proofing and Waterproofing, 716.
Automobiles.
  Tentative Specifications for Elliptical Springs for —, 549.
  Tentative Tests for Automobile Tire Fabrics, 791.

B

Bags.
  Tentative Tests for Cotton Fabrics for Use in — and Bagging Material, 794.
Bars.
  Tentative Specifications for Carbon-Steel — for Railway Springs with Special Silicon Requirements, 546.
  Tentative Specifications for Copper — for Locomotive Staybolts, 592.
Beam.
  Calculation of Energy Expended in Bending a —. Appendix III, Report of Committee A-1, 115.
Bearings.
  Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender —, 610.
Belting.
  Tentative Tests for Cotton Fabrics for Use in Hose, — and Similar Articles, 793.
Bituminous Materials (see also **Asphalt, Pitch, Road Materials**).
  Proposed Tentative Revision of Standard Methods for Distillation of — Suitable for Road Treatment. Appendix I, Report of Committee D-4, 474.
  Report of British Standard Nomenclature of — Appendix II, Report of Committee D-4, 476.
  Tentative Method for Determination of Softening Point of — other than Tar Products, 811.
Blooms.
  Tentative Specifications for Wrought-Iron Rolled or Forged — and Forgings for Locomotives and Cars, 573.
Boiler Steel.
  Tentative Specifications for Boiler and Firebox Steel for Stationary Service, 557.
Boiler Tubes.
  Tentative Specifications for Seamless Brass —, 599.
  Tentative Specifications for Seamless Copper —, 595.

Boxes.
Tentative Specifications for Canned Foods —, Nailed and Lock-Corner Construction, 723.
Tentative Specifications for Canned Foods —, Wirebound Construction, 730.

Brass.
Tentative Specifications for — Forging Rod, 603.
Tentative Specifications for Free-Cutting — Rod for Use in Screw Machines, 606.
Tentative Specifications for Seamless — Boiler Tubes, 599.

Brick.
Slag Test for Refractory — Used in the Iron and Steel Industry. Appendix, Report of Committee C-8, 314.

Bridge Timbers.
Tentative Specifications for Selected Structural Douglas Fir Bridge and Trestle Timbers, 704.

Broken Stone.
Tentative Form of Specifications for Certain Commercial Grades of —, 810.

Bronze.
Tentative Specifications for the Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent, 585.

Building Tile.
See **Tile.**

C

Cable.
Tentative Specifications for Insulated Wire and —: 30 per cent Hevea Rubber, 737.

Canned Foods Boxes.
Tentative Specifications for —. Nailed and Lock-Corner Construction, 723.
Tentative Specifications for — Wirebound Construction, 730.

Carbon Steel.
Tentative Specifications for — Bars for Railway Springs with Special Silicon Requirements, 546.
Tentative Specifications for Carbon Tool Steel, 562.

Cars.
Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings, 610.
Tentative Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and —, 573.

Cast Iron (see also **Malleable Iron**).
— Report of Committee A-3, 133. Discussion, 135.
Tentative Specifications for — Soil Pipe and Fittings, 576.

Castings.
Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, — and Finished Car and Tender Bearings, 610.
Tentative Specifications for Railroad Malleable-Iron —, 582.

Cement.
—. Report of Committee C-1, 196. Discussion, 198.
Clay and — Sewer Pipe. Report of Committee C-4, 293.
Tentative Recommended Practice for Laying Sewer Pipe, 701.
Tentative Specifications for — -Concrete Sewer Pipe, 647.
Tentative Specifications and Tests for Compressive Strength of Portland-— Mortars, 630.

Chemical Analysis.
See **Analysis.**

Clay Products.
Clay and Cement Sewer Pipe. Report of Committee C-4, 293.
Tentative Recommended Practice for Laying Sewer Pipe, 701.
Tentative Specifications for Clay Sewer Pipe, 634.

Coal-Tar Pitch.
See **Pitch.**

Coatings.
Preservative — for Structural Materials. Report of Committee D-1, 363.

Coke.
Tentative Methods for Laboratory Sampling and Analysis of —, 813.

Colorimetric Tests.
Suggested — for Organic Impurities in Sand. Appendix II, Report of Committee C-9, 327.

Compression Tests.
— of Tile. Appendix I, Report of Committee C-10, 338.

Concrete.
— and — Aggregates. Report of Committee C-9, 319.
Final Report of the Joint Committee on — and Reinforced — 202. Discussion, 263.
Reinforced —. Report of Committee C-2, 201. Discussion, 263.
Suggested Methods for Making and Testing Field Specimens of —. Appendix I, Report of Committee C-9, 322.
Tentative Specifications for Cement-— Sewer Pipe, 647.

Containers (see also **Boxes**).
Shipping —. Report of Committee D-10, 493.

Copper.
Tentative Methods for Analysis of Alloys of Lead, Tin, Antimony and —, 622.
Tentative Specifications for — Bars for Locomotive Staybolts, 592.
Tentative Specifications for — Plates for Locomotive Fireboxes, 588.
Tentative Specifications for Seamless — Boiler Tubes, 595.
Tentative Specifications for the Alloy: —, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent, 585.

Copper Wire.
Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber, 737.
Corrosion.
— of Iron and Steel. Report of Committee A-5, 143. Discussion, 175.
Cotton Fabrics (see also **Textile Materials**).
Tentative General Methods for Testing —, 829.
Tentative Specifications for 2½, 3, and 3½-in. Double-Jacketed Cotton Rubber-Lined Fire Hose for Public Fire Department Use, 732.
Tentative Tests for Automobile Tire Fabrics, 791.
Tentative Tests for — for Use in Bags and Bagging Material, 794.
Tentative Tests for — for Use in Hose, Belting and Similar Articles, 793.
Creosote Oil.
Tentative Methods for Analysis of —, 826.
Tentative Specifications for — for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing, 721.
Creosoted Timber.
Tentative Specifications for Southern Yellow-Pine Piles and Poles to be Creosoted, 710.
Tentative Specifications for Southern Yellow-Pine Timber to be Creosoted, 708.

D

Damp-proofing.
Tentative Specifications for Asphalt for Use in — and Waterproofing, 712.
Tentative Specifications for Coal-Tar Pitch for Use in — and Waterproofing, 717.
Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in — and Waterproofing, 721.
Tentative Specifications for Primer for Use with Asphalt for Use in — and Waterproofing, 716.
Definitions of Terms.
Tentative Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys, 838.
Tentative — Relating to the Gypsum Industry, 681.
Tentative — Relating to Materials for Roads and Pavements, 836.
Douglas Fir.
See **Fir.**
Drain Tile.
—. Report of Committee C-6, 311.

E

Electrical Insulation (see also **Insulated Wire, Insulating Materials**).
—. Report of Committee D-9, 489. Discussion, 491.
Elliptical Springs.
See **Springs.**

Energy.
Calculation of — Expended in Bending a Beam. Appendix III, Report of Committee A-1 on Steel, 115.
Executive Committee.
Annual Report of the —, 56.
Officers and Members of the —, 851.

F

Fabrics (see also **Textile Materials**).
Tentative General Methods for Testing Cotton —, 829.
Tentative Tests for Automobile Tire —, 791.
Tentative Tests for Cotton — for Use in Bags and Bagging Material, 794.
Tentative Tests for Cotton — for Use in Hose, Belting and Similar Articles, 793.
Ferrous Metals (see also **Iron, Steel**).
Tentative Standards for —. See Table of Contents, 5.
Field Specimens.
Suggested Methods for Making and Testing — of Concrete. Appendix I, Report of Committee C-9, 322.
Finished Castings.
See **Castings.**
Fir.
Tentative Specifications for Selected Structural Douglas — Bridge and Trestle Timbers, 704.
Fireboxes.
Tentative Specifications for Boiler and Firebox Steel for Stationary Service, 557.
Tentative Specifications for Copper Plates for Locomotive —, 588.
Fire Hose.
Tentative Specifications for 2½, 3, and 3½-in. Double-Jacketed Cotton Rubber-Lined — for Public Fire Department Use, 732.
Fireproofing.
—. Report of Committee C-5, 295. Discussion, 300.
Fire Tests.
Tentative Method for Control of — and Classification of Materials and Construction as Determined by Test, 679.
Fittings.
Tentative Specifications for Cast-Iron Soil Pipe and —, 576.
Forgings.
Tentative Specifications for Brass Forging Rod, 603.
Tentative Specifications for Wrought-Iron Rolled or Forged Blooms and — for Locomotives and Cars, 573.

G

Government Bronze.
See **Bronze.**
Gypsum.
Tentative Definitions of Terms Relating to the — Industry, 681.

H

Hevea Rubber.
See **Rubber.**
Hollow Tile.
See **Tile.**
Hose.
Tentative Specifications for Air-Line — for Pneumatic Tools, 763.
Tentative Specifications for 2½, 3, and 3½-in. Double-Jacketed Cotton Rubber-Lined Fire — for Public Fire Department Use, 732.
Tentative Tests for Cotton Fabrics for Use in —, Belting and Similar Articles, 793.
Hydrated Lime.
See **Lime.**

I

Ingots.
Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in —, Castings, and Finished Car and Tender Bearings, 610.
Insulated Wire.
Tentative Specifications for — and Cable: 30 per cent Hevea Rubber, 737.
Insulating Materials.
Electrical Insulation. Report of Committee D-9, 489. Discussion, 491.
Tentative Tests for Molded —, 778.
Iron.
Cast —. Report of Committee A-3, 133. Discussion, 135.
Corrosion of — and Steel. Report of Committee A-5, 143. Discussion, 175.
Preparation of — and Steel Surfaces for Painting. Report of Sub-Committee XIV of Committee D-1, 451.
Slag Test for Refractory Brick Used in the — and Steel Industry. Appendix, Report of Committee C-8, 314.
Tentative Specifications for Cast-— Soil Pipe and Fittings, 576.
Tentative Specifications for Railroad Malleable-— Castings, 582.
Tentative Specifications for Staybolt —, 564.
Tentative Specifications for Wrought-— Pipe, 568.
Tentative Specifications for Wrought-— Rolled or Forged Blooms and Forgings for Locomotives and Cars, 573.
Wrought —. Report of Committee A-2, 130.

L

Laboratory Sampling.
See **Sampling.**
Lead (see also **Red Lead**).
Tentative Methods for Analysis of Alloys of —, Tin, Antimony and Copper, 622.

Lime.
—. Report of Committee C-7, 312.
Tentative Specifications for Masons' Hydrated —, 661.
Linseed Oil.
—. Report of Sub-Committee V of Committee D-1, 377.
Locomotives.
Tentative Specifications for Copper Bars for Locomotive Staybolts, 592.
Tentative Specifications for Copper Plates for Locomotive Fireboxes, 588.
Tentative Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for — and Cars, 573.
Lubricants (see also **Oil**).
—. Report of Committee D-2, 462.
Tentative Tests for —, 767.
Lumbang Oil.
Report of Sub-Committee III of Committee D-1, 365. Appendix I, 366. Appendix II, 375.

M

Magnification Scales (see also **Micrographs**).
— for Micrographs. Report of Committee E-4, 508. Discussion, 509.
Malleable Iron.
Tentative Specifications for Railroad — Castings, 582.
Masons' Lime.
See **Lime.**
Materials.
Preservative Coatings for Structural —. Report of Committee D-1, 363.
Road —. Report of Committee D-4, 470.
Tentative Standards for Miscellaneous —. See Table of Contents, 7.
Textile —. Report of Committee D–13, 497.
Metallic Coatings.
Preservative — for Metals. Appendix, Report of Sub-Committee II of Committee A-5, 144.
Methods.
— of Testing. Report of Committee E-1, 499.
Suggested — for Making and Testing Field Specimens of Concrete. Appendix I, Report of Committee C-9, 322.
Tentative —. See Table of Contents, 5.
Micrographs.
Magnification Scales for —. Report of Committee E-4, 508. Discussion, 509.
Tentative Definitions and Rules Governing the Preparation of — of Metals and Alloys, 838.
Mortars.
Tentative Specifications and Tests for Compressive Strength of Portland-Cement —, 630.

N

Non-Ferrous Metals (see also **Brass, Copper, Spelter, Tin**).
- — and Alloys. Report of Committee B-2, 178.
- Tentative Methods for Analysis of Alloys of Lead, Tin, Antimony and Copper, 622.
- Tentative Specifications for Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings, 610.
- Tentative Standards for —. See Table of Contents, 6.

O

Officers.
- — and Members of the Executive Committee, 851.

Oil (see also **Lubricants**).
- Linseed —. Report of Sub-Committee V of Committee D-1, 377.
- Lumbang —. Report of Sub-Committee III of Committee D-1, 365.
- Perilla —. Report of Sub-Committee III of Committee D-1, 365.
- Tentative Methods for Analysis of Creosote —, 826.
- Tentative Specifications for Creosote—for Priming Coat with Coal- Tar Pitch for Use in Damp-proofing and Waterproofing, 721.

Organic Impurities.
- Suggested Colorimetric Tests for — in Sand. Appendix II, Report of Committee C-9, 327.

P

Paint (see also **Pigments, Preservative Coatings**).
- Methods of Analysis of — Materials. Report of Sub-Committee VIII of Committee D-1, 385.
- — Thinners other than Turpentine. Report of Sub-Committee XI of Committee D-1, 402.
- Preparation of Iron and Steel Surfaces for Painting. Report of Sub-Committee XIV of Committee D-1, 451.
- Testing of — Vehicles. Report of Sub-Committee III of Committee D-1, 365.

Papers.
- — and Publications. Report of Committee E-6, 529.

Pavements.
- Tentative Definitions of Terms Relating to Materials for Roads and —, 836.

Perilla Oil.
- Report of Sub-Committee III of Committee D-1, 365. Appendix I, 366. Appendix II, 375.

Pigments.
- Specifications for — Dry and in Oil when Marketed in the Form. Report of Sub-Committee XV of Committee D-1, 458.
- Tentative Methods for Routine Analysis of Dry Red Lead, 796.
- Tentative Methods for Routine Analysis of Yellow, Orange, Red and Brown — containing Iron and Manganese, 802.

Piles.
Tentative Specifications for Southern Yellow-Pine — and Poles to be Creosoted, 710.
Pine.
Tentative Specifications for Southern Yellow- — Piles and Poles to be Creosoted, 710.
Tentative Specifications for Southern Yellow- — Timber to be Creosoted, 708.
Pipe.
Clay and Cement Sewer —. Report of Committee C-4, 293.
Revision of — Threads. Report of Committee E-3, 504.
Tentative Recommended Practice for Laying Sewer —, 701.
Tentative Specifications for Cast-Iron Soil — and Fittings, 576.
Tentative Specifications for Cement-Concrete Sewer —, 647.
Tentative Specifications for Clay Sewer —, 634.
Tentative Specifications for Required Safe Crushing Strengths of Sewer — to carry Loads from Ditch Filling, 659.
Tentative Specifications for Wrought-Iron —, 568.
Pitch.
Tentative Specifications for Coal-Tar — for Use in Damp-proofing and Waterproofing, 716.
Tentative Specifications for Cresote Oil for Priming Coat with Coal-Tar — for Use in Damp-proofing and Waterproofing, 721.
Plates.
Tentative Specifications for Copper — for Locomotive Fireboxes, 588.
Tentative Specifications for Steel Tie —, 541.
Pneumatic Tools.
Tentative Specifications for Air-Line Hose for —, 763.
Poles.
Tentative Specifications for Southern Yellow-Pine Piles and — to be Creosoted, 710.
Portland Cement.
See **Cement.**
Preservative Coatings.
— for Structural Materials. Report of Committee D-1, 363.
Preservative Metallic Coatings.
— for Metals. Appendix, Report of Sub-Committee II of Committee A-5, 144.
President's Address.
See **Address.**
Primer.
Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing, 721.
Tentative Specifications for — for Use with Asphalt for Use in Damp-proofing and Waterproofing, 716.

Proceedings.
Summary of the — of the Twentieth Annual Meeting, 9.
Publications.
Papers and —. Report of Committee E-6, 529.

R

Rail.
The — Situation. Appendix II, Report of Committee A-1 on Steel, 111.
Railway (see also **Brass, Copper, Iron, Steel**).
Tentative Specifications for Carbon-Steel Bars for — Springs with Special Silicon Requirements, 546.
Tentative Specifications for Non-Ferrous Alloys for— Equipment in Ingots, Castings, and Finished Car and Tender Bearings, 610.
Tentative Specifications for Railroad Malleable-Iron Castings, 582.
Recommended Practice.
Tentative — for Laying Sewer Pipe, 701.
Red Lead.
Tentative Methods for Routine Analysis of Dry —, 796.
Refractory Materials.
Refractories. Report of Committee C-8, 313.
Slag Test for Refractory Brick Used in the Iron and Steel Industry. Appendix, Report of Committee C-8, 314.
Tentative Methods for Ultimate Chemical Analysis of —, 671.
Tentative Test for — under Load at High Temperatures, 665.
Tentative Test for Slagging Action of —, 669.
Regulations.
Changes in the — Governing Standing Committees. Appendix I, Report of Committee E-5, 516.
Reinforced Concrete.
Final Report of the Joint Committee on Concrete and —, 202. Discussion, 263.
—. Report of Committee C-2, 201. Discussion, 263.
Road Materials (see also **Aggregate, Rock, Stone**).
Report of Joint Conference Committee of Committees C-9 and D-4 on Provisional Definitions, Tests and Methods Pertaining to Non-Bituminous —. Appendix III, Report of Committee C-9, 334.
—. Report of Committee D-4, 470.
Tentative Definitions of Terms Relating to Materials for Roads and Pavements, 836.
Rock (see also **Stone**).
Tentative Test for Toughness of —, 773.
Rods.
Tentative Specifications for Brass Forging Rod, 603.
Tentative Specifications for Free-Cutting Brass Rod for Use in Screw Machines, 606.

Rubber.
— Products. Report of Committee D-11, 494.
Tentative Specifications for Air-Line Hose for Pneumatic Tools, 763.
Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea —, 737.
Tentative Specifications for 2½, 3, and 3½-in. Double-Jacketed Cotton —-Lined Fire Hose for Public Fire Department Use, 732.

S

Sampling.
Tentative Methods for Laboratory — and Analysis of Coke, 813.
Sand.
Suggested Colorimetric Tests for Organic Impurities in —. Appendix II, Report of Committee C-9, 327.
Sand-Cast Metals.
— and Alloys. Appendix II, Report of Sub-Committee III of Committee B-2, 182.
Screw Machines.
Tentative Specifications for Free-Cutting Brass Rod for Use in —, 606.
Screw Spikes.
Tentative Specifications for Steel —, 539.
Seamless Tubes.
See **Tubes.**
Sewer Pipe.
Clay and Cement —. Report of Committee C-4, 293.
Tentative Recommended Practice for Laying —, 701.
Tentative Specifications for Cement-Concrete —, 647.
Tentative Specifications for Clay —, 634.
Tentative Specifications for Required Safe Crushing Strengths of — to Carry Loads from Ditch Filling, 659.
Shipping Containers (see also **Boxes**).
—. Report of Committee D-10, 493.
Silicon.
Tentative Specifications for Carbon-Steel Bars for Railway Springs with Special — Requirements, 546.
Slag Test.
— for Refractory Brick Used in the Iron and Steel Industry. Appendix, Report of Committee C-8, 314.
Tentative Test for Slagging Action of Refractory Materials, 669.
Softening Point.
Tentative Method for Determination of — of Bituminous Materials other than Tar Products, 811.
Soil Pipe.
Tentative Specifications for Cast-Iron — and Fittings, 576.
Southern Yellow Pine.
See **Pine.**

Specific Gravity.
Tentative Test for Determination of Apparent — of Coarse Aggregates, 776.
Specifications.
Tentative —. See Table of Contents, 5.
Spelter (see also **Zinc**).
Proposed Revisions in Standard Specifications for —. Appendix I, Report of Committee B-2, 180.
Tentative Specifications for —, 615.
Spikes.
Tentative Specifications for Steel Screw —, 539.
Tentative Specifications for Steel Track —, 537.
Springs.
Tentative Specifications for Carbon-Steel Bars for Railway — with Special Silicon Requirements, 546.
Tentative Specifications for Elliptical — for Automobiles, 549.
Standards.
Tentative —. See Table of Contents, 5.
Standing Committees.
Changes in the Regulations Governing —. Appendix I, Report of Committee E-5, 516.
—. Report of Committee E-5, 512.
Statement of Sub-Committee on Classification of — and Standards. Appendix II, Report of Committee E-5, 519.
Staybolts.
Tentative Specifications for Copper Bars for Locomotive —, 592.
Tentative Specifications for Staybolt Iron, 564.
Steel.
Corrosion of Iron and —. Report of Committee A-5, 143. Discussion, 175.
Preparation of Iron and — Surfaces for Painting. Report of Sub-Committee XIV of Committee D-1, 451.
Slag Test for Refractory Brick Used in the Iron and — Industry. Appendix, Report of Committee C-8, 314.
—. Report of Committee A-1, 86. Discussion, 121.
Tentative Specifications for Boiler and Firebox — for Stationary Service, 557.
Tentative Specifications for Carbon- — Bars for Railway Springs with Special Silicon Requirements, 546.
Tentative Specifications for Carbon Tool —, 562.
Tentative Specifications for Elliptical Springs for Automobiles, 549.
Tentative Specifications for — Screw Spikes, 539.
Tentative Specifications for — Tie Plates, 541.
Tentative Specifications for — Track Spikes, 537.
Stone (see also **Rock**).
Tentative Form of Specifications for Certain Commercial Grades of Broken —, 810.

Structural Materials.
Preservative Coatings for —. Report of Committee D-1, 363.
Structural Timber.
See **Timber.**
Summary of the Proceedings.
— of the Twentieth Annual Meeting, 9.

T

Tender Bearings.
See **Bearings.**
Tentative Revisions of Standards.
—, 849.
Tentative Standards.
See Table of Contents, 5.
Testing (see also **Tests**).
Methods of —. Report of Committee E-1, 499.
Suggested Methods for Making and — Field Specimens of Concrete. Appendix I, Report of Committee C-9, 322.
Tentative General Methods for — Cotton Fabrics, 829.
— of Paint Vehicles. Report of Sub-Committee III of Committee D-1, 365.
Tests (see also **Testing**).
Absorption — of Tile. Appendix II, Report of Committee C-10, 353.
Compression — of Tile. Appendix I, Report of Committee C-10, 338.
Report of Sub-Committee on Effect of Form and Size of Test Piece. Appendix, Report of Committee E-1, 502.
Slag — for Refractory Brick Used in the Iron and Steel Industry. Appendix, Report of Committee C-8, 314.
Suggested Colorimetric — for Organic Impurities in Sand. Appendix II, Report of Committee C-9, 327.
Tentative Method for Control of Fire — and Classification of Materials and Construction as Determined by Test, 679.
Tentative —. See Table of Contents, 5.
— of Tile Walls. Appendix III, Report of Committee C-10, 359.
Textile Materials (see also **Fabrics**).
—. Report of Committee D-13, 497.
Thinners.
Paint — other than Turpentine. Report of Sub-Committee XI of Committee D-1, 402.
Threads.
Revision of Pipe —. Report of Committee E-3, 504.
Tie Plates.
Tentative Specifications for Steel —, 541.
Tile.
Absorption Tests of —. Appendix II, Report of Committee C-10, 353.
Compression Tests of —. Appendix I, Report of Committee C-10, 338.
Drain —. Report of Committee C-6, 311.
Hollow Building —. Report of Committee C-10, 335.
Tests of — Walls. Appendix III, Report of Committee C-10, 359.

Timber.
—. Report of Committee D-7, 483.
Tentative Specifications for Selected Structural Douglas Fir Bridge and Trestle Timbers, 704.
Tentative Specifications for Southern Yellow-Pine Piles and Poles to be Creosoted, 710.
Tentative Specifications for Southern Yellow-Pine — to be Creosoted, 708.
Tin.
Tentative Specifications for the Alloy: Copper, 88 per cent; —, 10 per cent; Zinc, 2 per cent, 585.
Tentative Methods for Analysis of Alloys of Lead, —, Antimony and Copper, 622.
Tire Fabrics.
Tentative Tests for Automobile —, 791.
Tool Steel.
Tentative Specifications for Carbon —, 562.
Tools.
Tentative Specifications for Air-Line Hose for Pneumatic —, 763.
Toughness.
Tentative Test for — of Rock, 773.
Track Spikes.
Tentative Specifications for Steel —, 537.
Trestle Timbers.
Tentative Specifications for Selected Structural Douglas Fir Bridge and —, 704.
Tubes.
Tentative Specifications for Seamless Brass Boiler —, 599.
Tentative Specifications for Seamless Copper Boiler —, 595.

V

Varnish.
—. Report of Sub-Committee IX of Committee D-1, 386.

W

Walls.
Tests of Tile —. Appendix III, Report of Committee C-10, 359.
Waterproofing.
Tentative Specifications for Asphalt for Use in Damp-proofing and —, 712.
Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and —, 717.
Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and —, 721.
Tentative Specifications for Primer for Use with Asphalt for Use in Damp-proofing and —, 712.
—. Report of Committee D-8, 487.

Wire.
Tentative Specifications for Insulated — and Cable: 30 per cent Hevea Rubber, 737.
Wrought Iron.
Tentative Specifications for Staybolt Iron, 564.
Tentative Specifications for — Pipe, 568.
Tentative Specifications for — Rolled or Forged Blooms and Forgings for Locomotives and Cars, 573.
—. Report of Committee A-2, 130.

Y

Yellow Pine.
See **Pine.**

Z

Zinc (see also **Spelter**).
Tentative Specifications for the Alloy: Copper, 88 per cent; Tin, 10 per cent; —, 2 per cent, 585.

AUTHOR INDEX.

A

Abbott, F. E.
  Discussion, 122.
Aertsen, G.
  Discussion, 127.
Aiken, W. A.
  Report of Committee D-8 on Waterproofing, 487.
Ashton, Ernest.
  Discussion, 271, 272.

B

Barrier, Edw. A.
  Report of Committee D-11 on Rubber Products, 494.
Bassett, W. H.
  Report of Committee E-4 on Magnification Scales for Micrographs, 508.
Bates, P. H.
  Report of Committee C-1 on Cement, 196.
  Discussion, 274.
Bell, M. L.
  Report of Committee C-8 on Refractories. Appendix: Slag Test for Refractory Brick Used in the Iron and Steel Industry, 314.
Bleininger, A. V.
  Report of Committee C-8 on Refractories, 313.
Bragg, C. T.
  Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 390.
Brown, C. G.
  Discussion, 175.
Burleigh, W. F.
  Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.
Burrows, C. W.
  Statement of Sub-Committee of Committee E-5 on Classification of Standing Committees and Standards, 519.

C

Campbell, William
  Report of Committee B-2 on Non-Ferrous Metals and Alloys, 178.
Capp, J. A.
  Report of Sub-Committee III of Committee B-2 on Sand-Cast Metals and Alloys, 188.

Carnahan, R. B., Jr.
Discussion, 176.

Carpenter, A. W.
Report of Sub-Committee XIV of Committee D-1 on the Preparation of Iron and Steel Surfaces for Painting, 451.

Carson, Harry Y.
Discussion, 135.

Chapman, Cloyd M.
Report of Sub-Committee XI of Committee D-1 on Paint Thinners other than Turpentine, 402.

Clamer, G. H.
Report of Sub-Committee III of Committee B-2 on Sand-Cast Metals and Alloys, 186.

Cole, E. J.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.

Collins, T. R.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 370.

Comstock, George F.
Discussion, 509.

Conwell, E. L.
Report of Committee C-7 on Lime, 312.

Corse, W. M.
Report of Sub-Committee III of Committee B-2 on Sand-Cast Metals and Alloys, 190.

Coyle, Francis B.
Discussion, 124.

D

Darke, J. M.
Discussion, 124, 125, 126.

Davies, G. C.
Report of Committee A-3 on Cast Iron, 133.

Devries, R. P.
Discussion, 126, 129.

Dewar, John
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 394.

Dunn, B. W.
Report of Committee D-10 on Shipping Containers, 493.

E

Ehrenfeld, C. H.
Discussion, 127.

Enright, Bernard.
Discussion, 198, 264.

F

Ferguson, Lewis, R.
Report of Committee C-9 on Concrete and Concrete Aggregates, 319.
Fort, E. J.
Report of Committee C-4 on Clay and Cement Sewer Pipe, 293.

G

Gardner, H. A.
Report of Sub-Committee III of Committee D-1 on Testing of Paint Vehicles, 365. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 366.
Gibboney, J. H.
Discussion, 122, 175, 176.
Gibbs, A. W.
Addresses by Past Presidents, 50.
Goodell, J. M.
Discussion, 273.
Greenman, R. S.
Report of Committee C-1 on Cement, 196.
Discussion, 200.

H

Hartshorne, Wm. D.
Report of Committee D-13 on Textile Materials, 497.
Hatt, W. K.
Discussion, 272, 276, 280.
Hering, Rudolph.
Report of Committee C-4 on Clay and Cement Sewer Pipe, 293.
Hoffman, N. B.
Discussion, 124.
Holton, E. C.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 390.
Howe, Henry M.
Addresses by Past Presidents, 54.
Discussion, 128.
Hubbard, Prévost.
Report of Committee D-4 on Road Materials, 470.
Hull, W. A.
Discussion, 307.
Humphrey, Richard L.
Report of Committee C-2 on Reinforced Concrete, 201.
Statement of Sub-Committee of Committee E-5 on Classification of Standing Committees and Standards, 519.
Discussion, 263, 270, 271, 275, 277.

Hunnings, S. V.
Report of Committee A-2 on Wrought Iron, 130.
Hunt, Capt. Robert W.
Addresses by Past Presidents, 52.
Discussion, 121, 122, 123.

I

Ingalls, E.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 390.
Ingalls, F. P.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.
Ingberg, S. H.
Discussion, 308.

J

Jones, J. L.
Report of Sub-Committee III of Committee B-2 on Sand-Cast Metals and Alloys, 187, 191, 194.

K

Kellogg, J. W.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 369.
Kinney, W. M.
Discussion, 273, 279.

L

Lanza, Gaetano.
Report of Committee E-1 on Methods of Testing, 499.
Law, Leroy M.
Report of Committee D-8 on Waterproofing, 487.
Lindsay, R. W.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 371.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.

M

Macgregor, James S.
Report of Committee C-7 on Lime, 312.
Mackenzie, K. G.
Report of Committee D-2 on Lubricants, 462.
Marburg, Edgar.
Annual Report of the Executive Committee, 56.
Report of Committee E-6 on Papers and Publications, 529.

Marston, A.
Report of Committee C-6 on Drain Tile, 311.

Martin, E. W.
Report of Sub-Committee V of Committee D-1. Appendix: Reports of Analysts, 379.

Mathews, J. A.
Discussion, 510.

Merriman, Mansfield.
Addresses by Past Presidents, 55.

Miller, Rudolph P.
Report of Committee C-5 on Fireproofing, 295.

Mills, C. B.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 371.
Report of Sub-Committee V of Committee D-1. Appendix: Reports of Analysts, 378.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.

Moldenke, Richard.
Report of Committee A-3 on Cast Iron, 133.
Discussion, 122.

Moore, H. F.
Report of Sub-Committee of Committee E-1 on Effect of Form and Size of Test Piece, 502.

N

Nemzek, L. P.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 370.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.

Nesbitt, C. E.
Report of Committee C-8 on Refractories. Appendix: Slag Test for Refractory Brick Used in the Iron and Steel Industry, 314.

Nolan, Thomas.
Discussion, 275.

P

Page, L. W.
Report of Committee D-4 on Road Materials, 470.

Patch, N. K. B.
Report of Sub-Committee III of Committee B-2 on Sand-Cast Metals and Alloys, 187, 188.

Pickard, Glenn H.
Report of Sub-Committee V of Committee D-1 on Linseed Oil, 377. Appendix: Reports of Analysts, 379.

Probeck, E. J.
Report of Sub-Committee V of Committee D-1. Appendix: Reports of Analysts, 384.
Provine, L. H.
Report of Committee C-10 on Hollow Building Tile, 335.
Provost, A. J., Jr.
Report of Committee C-4 on Clay and Cement Sewer Pipe, 293.

R

Rawdon, H. S.
Discussion, 176.
Rhett, A. H.
Discussion, 264.
Rogers, Allen.
Report of Sub-Committee IX of Committee D-1 on Varnish, 386. Appendix: Reports of Analysts, 396.

S

Sabin, A. H.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.
Seaton, M. Y.
Report of Sub-Committee V of Committee D-1. Appendix: Reports of Analysts, 382.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 390.
Shuman, J. J.
Discussion, 123.
Skinner, C. E.
Report of Committee D-9 on Electrical Insulation, 489.
Report of Committee E-5 on Standing Committees, 512.
Discussion, 491, 492.
Slater, W. A.
Discussion, 175, 177, 279, 300, 303, 304, 305, 491, 492.
Smith, H. E.
Discussion, 491.
Smither, F. W.
Report of Sub-Committee VIII of Committee D-1 on Methods of Analysis of Paint Materials, 385.
Spring, L. W.
Report of Sub-Committee III of Committee B-2 on Sand-Cast Metals and Alloys, 192.
Stevenson, A. A.
Annual Address by the President—Our Society, 34.
Annual Report of the Executive Committee, 56.

Stone, G. C.
Report of Sub-Committee XV of Committee D-1 on Specifications for Pigments Dry and in Oil when Marketed in the Form, 458.

Strehan, G. E.
Discussion, 301, 303, 304, 305.

T

Talbot, Arthur N.
Addresses by Past Presidents, 51.
Discussion, 276, 280.

Thackray, G. E.
Discussion, 122.

Thompson, G. W.
Report of Committee D-1 on Preservative Coatings for Structural Materials, 363.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 371.
Report of Sub-Committee V of Committee D-1. Appendix: Reports of Analysts, 378.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 391.

Thompson, Sanford E.
Report of Committee C-9 on Concrete and Concrete Aggregates, 319.
Discussion, 272, 278.

Topping, W. S.
Report of Committee D-10 on Shipping Containers, 493.

Turneaure, F. E.
Report of Committee C-2 on Reinforced Concrete, 201.

V

Van Gundy, C. P.
Report of Committee D-2 on Lubricants, 462.

von Schrenk, Hermann.
Report of Committee D-7 on Timber, 483.

Voorhees, S. S.
Report of Committee A-5 on Corrosion of Iron and Steel, 143.
Statement of Sub-Committee of Committee E-5 on Classification of Standing Committees and Standards, 519.
Discussion, 128, 175, 176.

W

Walker, P. H.
Report of Committee D-1 on Preservative Coatings for Structural Materials, 363.

Waring, F. M.
Report of Committee D-11 on Rubber Products, 494.

Warwick, C. L.
Report of Committee A-1 on Steel, 86.

Webbert, L. P.
Report of Sub-Committee III of Committee B-2 on Sand-Cast Metals and Alloys, 182.

Wertz, F. A.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 372.
Report of Sub-Committee V of Committee D-1. Appendix: Reports of Analysts, 380.
Report of Sub-Committee IX of Committee D-1. Appendix: Reports of Analysts, 390.

White, G. D.
Report of Sub-Committee III of Committee D-1. Appendix: Reports of Analysts on Lumbang and Perilla Oils, 370.

Wig, R. J.
Discussion, 266, 274, 278, 280.

Wille, H. V.
Report of Committee E-3 on Revision of Pipe Threads, 504.

Woolson, Ira H.
Report of Committee C-5 on Fireproofing, 295.

Y

Young, C. D.
Report of Committee A-1 on Steel, 86.
Discussion, 121, 125.

Young, J. B.
Report of Committee A-2 on Wrought Iron, 130.